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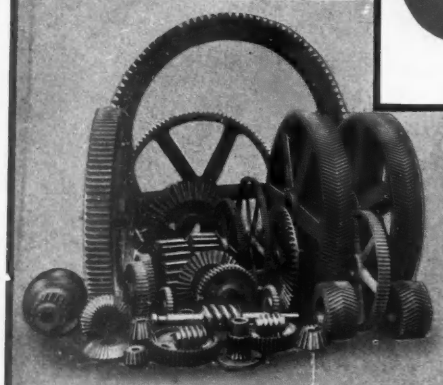

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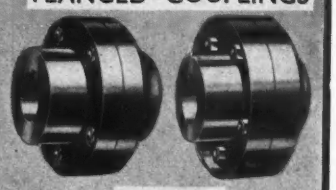

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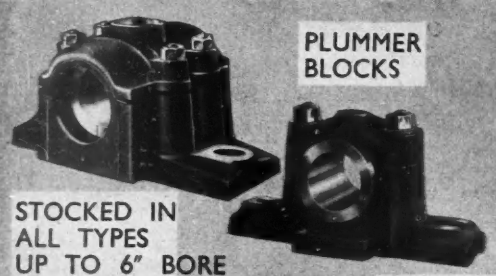

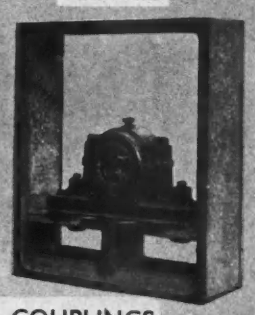

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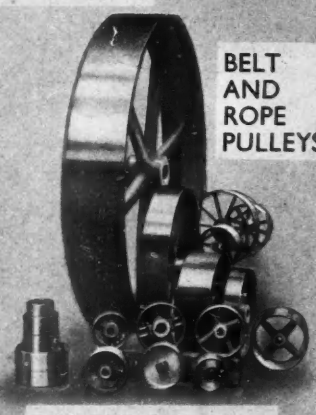

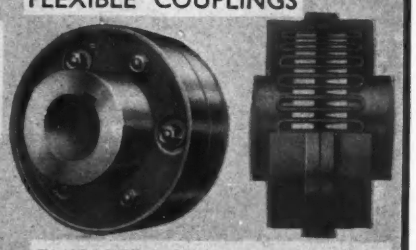

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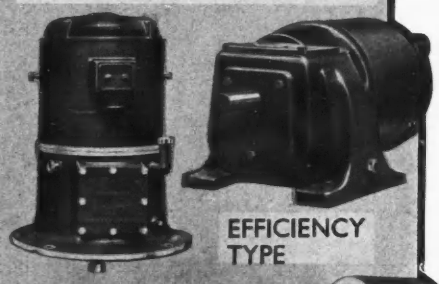

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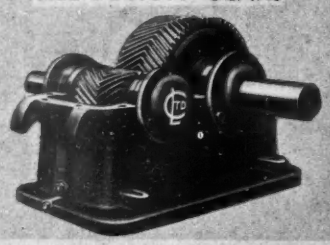

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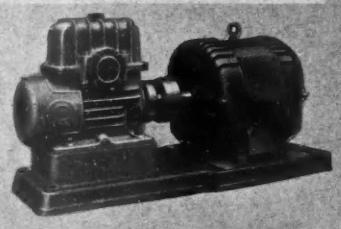

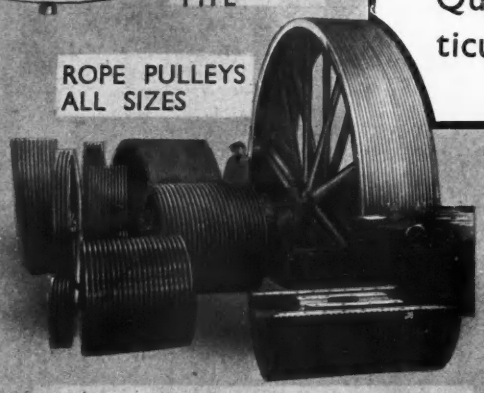

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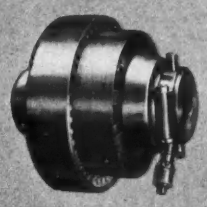

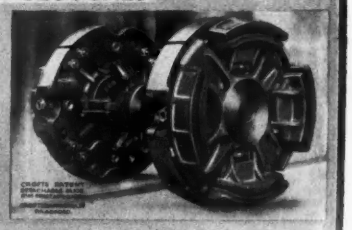

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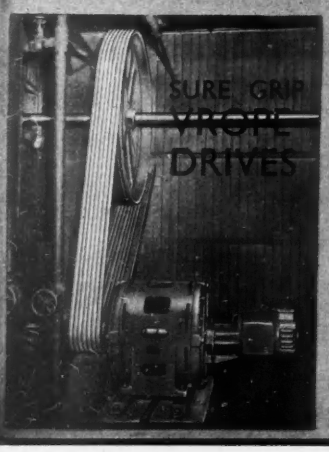

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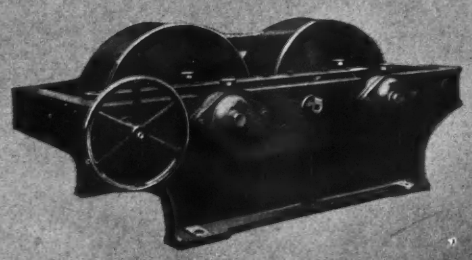

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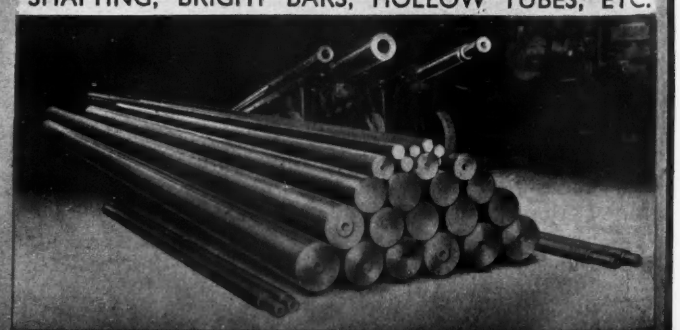

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British Overseas Airways Corporation

At a conference held in London last week, Mr. Clive Pearson, who has succeeded Sir John Reith as chairman of the British Overseas Airways Corporation, said that progress with the air lines with which the corporation would concern itself when it acquired the undertakings of Imperial Airways, Ltd., and British Airways, Ltd., on April 1st, would depend entirely on war conditions. It was unlikely that a North Atlantic passenger service would be begun this year, but mails would be carried on this route. The mail service was expected to start soon after the base in Newfoundland was clear of ice, which was towards the end of May. The South Atlantic project of British Airways was to be held in abeyance. The corporation would buy a limited number of D.H.95 aeroplanes, generally known as the Flamingo type, and it would maintain a constant watch on commercial aircraft development throughout the world so that at any moment it would be able, if the war permitted, to issue specifications for commercial aircraft which would be up to date. In reference to criticisms that had been made regarding British commercial flying, he said that there seemed to have been some lack of decision and drive, as was instanced by the confusion over the Langstone harbour project. Fundamentally, however, the fault lay less with the operating companies or the present Government than with Government departments some years ago.

The Late Edouard Branly

The death of Edouard Branly in Paris, on Sunday, March 25th, in his 96th year, closes a long career of useful investigation in the electro-mechanical and physical sciences that continued until the end of his life. The son of a professor and born at Amiens in 1844, he prepared to follow his father's calling and studied natural and physical sciences as well as medicine. In 1875 Branly was appointed professor of physical science at the newly created Catholic Institute in Paris where he remained to carry on work in his laboratory for the rest of his life. It was about 1888, that the experiments of Hertz awakened interest in wireless transmission, although in 1879 Hughes discovered that a microphone was sensitive to electrical disturbances, and five years later Calzecchi-Onesti showed that metal filings enclosed in a tube between two electrodes became a conductor under the effect of an electromotive force induced by a rupture of current. Branly developed the metal filing tube, and in 1890 he presented to the Académie des Sciences a full account of his experiments with a transmitter and receiver which marked the first practical stage in wireless transmission. Then followed Lodge with an adaptation of Hertzian oscillators to a modified Branly tube, and then Marconi, who, after his first radio communication between Dover and Boulogne in 1899, sent a telegram to Branly acknowledging his indebtedness to his French precursor. While always working in his laboratory at the Catholic Institute and contributing largely to electromechanical and physiological investigations, Branly is commonly associated almost entirely with his coherer, which has acquired for him in France the name of the "Father of Wireless." An extremely modest man, he was engrossed in his work and took no credit for his achievements. Branly was constantly in his laboratory with his assistants, and on the outbreak of the war he was removed to the provinces, but was allowed to return to Paris and continue his work at the laboratory, this time alone, until he was laid up with an illness induced by the severe weather, from which he did not recover. Branly was decorated with the Grand Croix of the Legion of Honour and was accorded a national funeral.

British Shipping

The conditions under which British shipping companies are operating under wartime conditions were mentioned by Sir Philip Haldin, chairman and managing director of Lamport and Holt Line, Ltd., when addressing the annual general meeting last week. After referring to the success of new and fast motor vessels capable of bringing oranges and other fresh fruit to this country from Brazil, in non-refrigerated holds, under the peaceful conditions ruling during the first eight months of 1939, he mentioned that, as from February 1st, 1940, all liner tonnage had been requisitioned and that all liner companies were now pooling their resources under the direction of the Ministry of Shipping. The result had been the complete abolition of sailings such as that between the United States and Brazil established by the company 95 years ago. An attempt was being made to maintain that service with neutral tonnage chartered at high rates and at considerable loss. The loss, however, could not be indefinitely faced and it was hoped that the Ministry of Shipping would apportion two or three of the company's vessels to maintain the service. Sir Philip also remarked that unless the government allowed shipowners to make sufficient profit to provide for depreciation, pay dividends, and in addition put something to reserve no shipping company could possibly be in service for long. The government, he was pleased to state, was considering the matter, and had promised to help after hostilities ceased. Referring to rates of hire he said those paid to British companies were microscopical compared to the rates paid to neutrals and that the profits which the Ministry of Shipping must be making after paying the meagre rates of hire to British vessels must be enormous. It was a tragedy that those profits should have to be used to recoup the losses incurred in paying neutrals enormous freights instead of going to help British shipping which had been long neglected.

The Late Sir John Gilmour

It is with deep regret that we have to record the death of Colonel the Right Hon. Sir John Gilmour, the Minister of Shipping, which took place suddenly at his home, 6, Cadogan Square, London, on Saturday, March 30th. Sir John, who was only 63 years of age, died in harness, since he was at work at the Ministry late on Friday evening. It may be recalled that he was appointed Minister of Shipping on Saturday, October 14th, and at once started to organise the new Ministry. Sir John was born in 1876, at Montrave, near Leven, in Fife, and was educated at Trinity College, Glenalmond, and Edinburgh University, and at Trinity Hall, Cambridge. He served in the South African War, and the Great War, and was awarded the D.S.O. He was a keen agriculturalist, and a director of the Highland and other agricultural societies, a member of the Scottish Agricultural Organisation Society, and of the Joint Board of the agricultural associations of England, Ireland, and Scotland. He was also a director of the Caledonian Railway Company, until it became merged with the London, Midland, and Scottish Railway after the war. One of the most popular members of the House of Commons, he served in several ministerial offices. In 1931, he was Minister of Agriculture and Fisheries, and later Home Secretary, a position which he held until the summer of 1935. His appointment to the Ministry of Shipping gave rise to some criticism on the part of those who thought that the office should have been filled by someone more closely associated with shipping, and the shipping and shipbuilding industry. That criticism was met by Sir John's appointment to the Ministry of advisors and assistants drawn from the industry, and as late as March 18th, he gave in the House of Commons a spirited defence and explanation of the work of his department. Up to the last he showed constant and intense interest in all that relates to British shipping and the welfare of British seamen. Of him it may be truly said that he laid the foundations of the Ministry of Shipping and that the Ministry is now equipped to meet any demands which may be made upon it.

Associated Electrical Industries, Ltd.

In the course of his chairman's address at the fortieth annual general meeting of Associated Electrical Industries, Ltd., held on Friday, March 29th, at Bush House, London, Sir Felix J. C. Pole said that the company was continuing its policy of securing as much export business as possible. To that end it was maintaining an efficient organisation abroad, and was keeping in personal contact with overseas markets. Exports, Sir Felix went on to say, were more than ever necessary in wartime, and were rightly considered by the Government as only second in importance to the essential requirements of the fighting forces. The Government through the export council which had been appointed by the Board of Trade appeared to contemplate giving more assistance than hitherto to exporting companies. In that connection his company had pointed out the difficulty of obtaining large contracts for electrical and mechanical installations because of the risk incidental to quoting firm prices in view of rising costs of wages and materials. Some of our foreign competitors were not faced with this trouble, and it was felt that the British Government should assist the manufacturer in dealing with this problem. Many orders, Sir Felix said were continuing to be received from the Dominions, the Colonies, and foreign countries, the most recent order being from Turkey for the construction of a large power station at Catal Agzi, the value of which was about £1,500,000. The Metropolitan-Vickers Electrical Company has on hand a larger volume of orders than ever before for turbo-alternator sets transformers, switchgear equipment, hydro-electric rolling mill equipment, hydro-electric installations, electric locomotives, and other electrical apparatus. That company had a record number of employees, while as regards all the companies of the Associated Electrical group, the orders on hand exceeded £19,000,000. The number of employees was the highest in their history, and was still growing. He paid warm tribute to the spirit of goodwill and trust which existed between the management and its employees.

Census of Industry

The Factory Undertaking's (Record and Information) (No. 1) Order, 1940, was issued last Monday, April 1st, by the Ministry of Supply under the (Defence (General) Regulations. It applies to all factories, and gives power to require employers to furnish specified information regarding products manufactured and labour employed. Under its authority a census of the skilled, semi-skilled, and unskilled labour in certain essential wartime industries has been ordered by the Ministry of Supply and will be undertaken immediately by the Ministry of Labour and National Service. The industries first to be affected are to be motor vehicle and aircraft manufacture, engineering, and shipbuilding and ship-repairing. Employers in these three industries will receive tabulated forms asking for the required information. Co-operation is compulsory, but it is expected that firms will willingly comply. The forms are to be returned by April 10th, and are expected to provide information of the proportion of the labour employed on production for the war effort or in the export trade or for the home market; to yield information as to the distribution of skilled labour among the various industries; and to assist area supply boards in dealing with problems connected with the planning of production. The intention is to call for similar returns each quarter, and the area of inquiry will be extended to other industries as and when circumstances require the extension. The census will not only show the numbers and whereabouts of skilled men and the kinds of work upon which they are engaged, but will also give an indication of the factory space available, and the proportion of space and plant which is engaged on Government or other work. Particulars will have to be given by each firm of its main peacetime products, and of the products which have been or are being manufactured on Government account. Individual returns from the various firms affected will be treated as confidential. Publication of the whole of the information gained might give valuable information to the enemy, but it is possible that certain broad conclusions may be made available to the public when the results of the census have been collated.

The Hoffmann Manufacturing Company, Ltd.

At the annual general meeting of the Hoffmann Manufacturing Company, Ltd., which was held in London on Friday, March 29th, the speech of Mr. Robert Armitage was read by Mr. A. O. Peech, who presided in the absence of the chairman of the company. In the course of his speech, Mr. Armitage referred to the work of the company during the past year and said 'that although the financial results would no doubt be considered satisfactory, 1939 had been a year of exceptional difficulty for the company, in common with many others. As the year advanced it became clear that the demands upon the company would reach new records quickly. Every possible effort was made to meet the demand, but the usual difficulties in connection with manufacture under wartime circumstances, the loss of some hundreds of men to the Colours, and the necessary training of a large number of employees for replacement had had to be overcome. At the instance of the Government, the company was erecting at its own cost a new factory in another part of the country. The work in connection with setting up of the new works was being pushed forward in every way. The directors had decided, he said, that in connection with the new works a separate company should be formed, and it had been registered under the name of Hoffmann Gloucester, Ltd. The whole of the shares of the new company were to be held by the parent company. The subsidiary company in the United States of America continued to prosper, and expansion was taking place as the demand required. To some extent it had been possible to draw on the American works to augment our home production. Naturally there had been no recent information concerning the associated company in Germany, but ample provision had been made in the accounts to meet any contingency of that kind.

The Mechanism of Magnetisation

By T. F. WALL, D.Sc.*

No. III

(*Continued from page 297, March 29th*)

§ 11. *The Interpretation of Coercive Force.*—The boundary wall conditions between neighbouring domains, as discussed already in § 10 in accordance with R. Becker's interpretation of the initial susceptibility κ_o, cannot be applied when neighbouring domains are magnetised in directly opposing axes. The operation of the boundary wall between neighbouring domains when they are magnetised in direct opposition will now be considered in some detail.

The magnetisation curve of ferro-magnetic materials is now believed to be realised over the range *a b*, Fig. 33, by a process which is known as the "Barkhausen effect" or, alternatively, the "Barkhausen jump." That is to say, there is experimental evidence which shows that the increase of

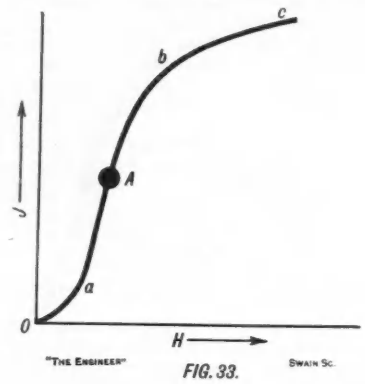


FIG. 33.

the intensity of magnetisation over the range *a b* is not attained by a steady, smooth increase as the magnetising force H increases, but for any point such as A the magnetising force will have to increase by a definite amount before there is any further increase in the intensity of magnetisation J. When, however, the magnetising force has increased by the requisite amount the intensity J will increase by a definite step or jump. This jump can be observed as a noise or click in a telephone receiver which is coupled by a valve amplifier to the wire which is being magnetised. There is evidence to show that the average jump in the intensity of magnetisation J corresponds to the reversal of magnetisation in a region of the material of volume of about 10^{-6} c.cm.; that is, corresponding to the size of the Weiss domain.

The magnitude of this jump can, however, be controlled by means of a procedure which was first fully investigated by Preisach. It was found that if a mechanical load was applied to the wire which is being magnetised the magnitude of the jump could be increased. For materials with a positive magneto-striction effect it has been found to be possible to produce the full magnetisation of a wire by means of a single Barkhausen jump. Preisach used a thin wire of (60 nickel–40 iron) alloy and loaded it to a stress $\sigma = 15$ kilos. per square millimetre[28] and the null magnetisation curve shown in Fig. 34 was then obtained. It will be seen that when a magnetising force of about 0·05 oersted is applied the intensity of magnetisation springs in one jump to its full saturation value and any further increase of the magnetising force produces no further increase of the intensity of magnetisation. That is to say, the portion *a b* of the null magnetisation curve is a vertical straight line and the portion *b c* is a horizontal straight line.

The physical interpretation of this special character of the null magnetisation curve is as follows:—Since the wire has a positive magneto-striction effect the tensile stress σ due to the load causes the domains to align themselves with their axes in the direction of the tension which forms a preferential direction for positive magneto-striction, as has already been considered in § 9 with reference to Fig. 26 *a*. This state is shown diagrammatically in Fig. 34 *a*, from which it will be seen that the domains are all aligned in the direction of the applied tensile stress, but that they mutually neutralise each other's effect, so that the magnetisation of the material as a whole is zero; in other words, the material is completely demagnetised, but the domains are set in the preferential direction as determined by the direction of the applied stress and the positive nature of the magneto-striction effect.

When a magnetising field of the requisite strength H_o is applied, those of the Weiss domains which are aligned directly opposite to H_o turn through 180 deg., so that the condition will then correspond to Fig. 34 *b*. If now the magnetising field H_o be reduced to zero the saturation intensity J_s is still maintained, as shown by Fig. 34, so that the remanence J_r is equal to the saturation intensity J_s, and not until the field has been increased in the negative direction to some value H_c, which is greater than H_o, will the domains all turn through 180 deg., and the material becomes magnetised to saturation in the opposite direction, as shown in Fig. 34 *c*—that is to say, a single Barkhausen jump of about $2J_s$ will have been produced. Further increase of H_c in the negative direction

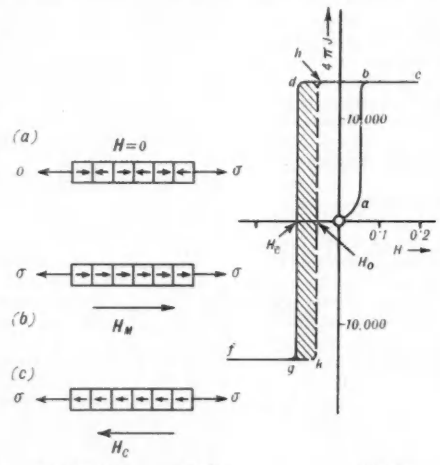


FIG. 34.

does not further increase the intensity of magnetisation and the condition is then defined by the horizontal line *g f* in Fig. 34.

In this way a rectangular hysteresis loop is obtained of which the half-loop *c b d g f* is shown in Fig. 34, and clearly the whole of the electromagnetic energy which is absorbed in magnetising the wire will be irrecoverable, since the demagnetising condition is defined by the horizontal line *b c*; this will also be seen by reference to Fig. 28, § 9. The field strength H_c necessary to cause the reversal of magnetisation in Fig. 34 is the coercive force.

The publication of Preisach's experimental results for the rectangular hysteresis loop suggested to I. Langmuir that it was most improbable that the turning of the Weiss domains through 180 deg. would occur simultaneously throughout the wire, but rather that it would originate at some place where there was some inhomogeneity which was favourable to this reversal and that the reversal would then spread throughout the wire at a finite speed.

K. J. Sixtus and L. Tonks, following up this suggestion of Langmuir, devised an experimental method to find out whether this kind of effect did, in fact, take place. They soon found that in order to promote the Barkhausen jump of $2J_s$, it was not necessary to maintain the field of strength H_c throughout the wire, but that this jump could not be obtained unless the field strength of at least H_o was maintained throughout the wire. That is to say, it was possible by impressing a magnetising field of strength H_o throughout the wire, and then at one place in the wire to superimpose another field of strength $H_c - H_o$, the reversal at this place would be effected, and would then travel throughout the whole length of the wire at a speed which was considerably less than the speed of sound waves in the wire. The maximum speed of travel of this reversal wave which Sixtus and Tonks measured was about 1000 metres per second, whereas the speed of sound waves in iron is about 5000 metres per second.[29]

The experimental results of Sixtus and Tonks definitely established the fact that the reversal of the Weiss domains did not occur simultaneously throughout the wire, but was produced by a reversal at one place which was favourable for the development of this effect, and it then travelled at a finite speed as a Barkhausen surge.

The speed of travel of this reversal of the saturation intensity from $+J_s$ to $-J_s$ is governed by the consequent losses of which the eddy current loss is an important constituent. A general idea of the factors which are involved in calculating the eddy current loss is obtained as follows:—

If the specimen is a wire of *a* cm. radius, and if an element of the wire of 1 cm. in length be considered, the electro-magnetic energy which is supplied to bring about the double Barkhausen jump of $2J_s$ will be given by the shaded area in Fig. 34. The magnitude of this energy is found by means of the expression (10*a*), § 3, viz.: $2J_s(H - H_o)$ ergs per cubic centimetre of the wire. But the volume of the element of 1 cm. in length is πa^2 cubic centimetre, so that the electro-magnetic energy which is supplied to produce the reversal of saturation intensity is

$$2J_s(H - H_o)\pi a^2 10^{-7} \text{ joules} \quad . \quad (27)$$

It will be assumed as a first approach that the whole of this energy is dissipated in eddy current loss. This loss may be written in the form

$$\frac{e^2}{r}\delta t \text{ joules} \quad . \quad . \quad . \quad . \quad (28)$$

If a single turn of wire is arranged on the wire, then *e* volts is the value of the E.M.F. induced in this search coil. If two such single-turn search coils are arranged so that one is at one end of the elementary length of the wire and the other is at the other end, then δt second is the time which is required for the double Barkhausen jump to pass along the wire from one search coil to the other. This time can, of course, be measured by means of oscillographic records and will then be a measure of the speed of travel of the Barkhausen jump.

Now the resistance *r* is equal to $\frac{\rho}{\pi a^2}$ where ρ is the specific resistance of the wire. Also,

$$e = \frac{\Delta\Phi}{\delta t . 10^8} = \frac{2.4\pi J_s . \pi a^2}{\delta t . 10^8} \text{ volts,}$$

so that

$$\frac{e^2}{r}\delta t = \left(\frac{2.4\pi J_s . \pi a^2}{\delta t . 10^8}\right)^2 \frac{\pi a^2}{\rho}\delta t \quad . \quad (29)$$

Equating expressions (27) and (28) and making use of expression (29) gives

$$\delta t = \frac{\Delta\Phi}{H - H_o}\frac{1}{10^9}\frac{1}{\rho}4\pi^2 a^2 \text{ second} \quad . \quad (30)$$

A comparison of the results given by this expression (30) with the values of the time as measured from oscillographic records shows that for a given wire the relationship between the calculated and the measured values is a constant factor for varying values of the magnetising force $H - H_o$, the measured values of the time being greater than the values given by the expression (30).

It has already been pointed out that for the reversal of neighbouring domains through 180 deg. R. Becker's interpretation of initial susceptibility fails. When neighbouring domains are magnetised so that their magnetic axes are in direct opposition it is not a feasible assumption that the boundary separating the domains shall be of the thickness corresponding to the dimensions of one atom, since the maintenance of such a sharply defined boundary wall would invoke very powerful exchange forces. The conditions which determine the stable thickness of the boundary between neighbouring domains of which the magnetic axes are displaced by 180 deg. can be seen by considering the simplest possible case as follows.[30] In Fig. 35 *a* are shown two neighbouring domains, the boundary between them being of thickness δ. The three rectangular axes O *x*, O *y*, and O *z* are marked in so that the boundary surface is parallel to the *y z* plane. A tensile stress σ is applied in the direction of the O *z* axis, as is shown in Fig. 35 *a*, and the material is assumed to have a positive magneto-striction effect.

For the domain on the left of Fig. 35 *a* the magnetic axis is directed upwards and for the domain on the right the axis is directed downwards. The electron spins are thus aligned upwards in the left-hand domain and are consequently displaced by 180 deg. from the alignment

* Department of Electrical Engineering, Sheffield University.

[28] 1 kilo. per square millimetre = 1420 lb. per square inch.

[29] For the method of measuring the speed of travel of stress surges in steel wires, reference may be made to T. F. Wall., THE ENGINEER, September 13th, 1935.

[30] See W. Döring, "Probleme der technischen Magnetisierungskurve."

of the electron spins in the right-hand domain. In the shaded area the electron spins are assumed to change gradually in direction through 180 deg., as is indicated in Fig. 35 *b*.

To make the treatment as simple as possible it is assumed that the electron spins in the boundary region will only be a function of the x co-ordinates.

Let C be the work done per cubic centimetre in displacing the magnetisation from the preferential direction. That is to say, for a material with positive magneto-striction effect, from the direction of the applied tensile stress to a direction at right

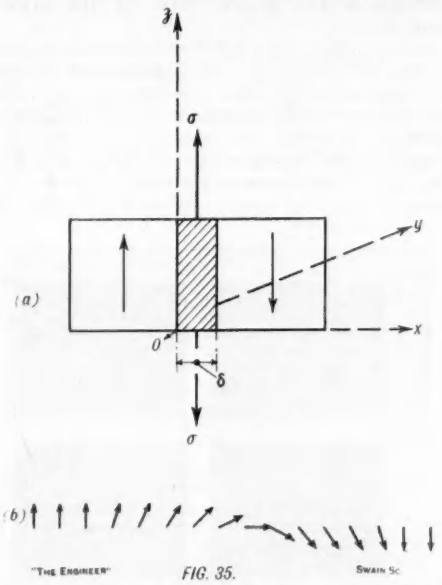


FIG. 35.

angles to this preferential direction. Then C will be given by the expression

$$C=\frac{3}{2}\lambda_s\sigma$$

as has already been shown in § 8 with reference to Figs. 24, 25, and 26. The work which must be expended per square centimetre of boundary surface will then be

$$k\,C\,\delta \quad . \quad . \quad . \quad . \quad . \quad . \quad (31)$$

because the volume which will be displaced from the preferential direction (*i.e.*, the direction of the stress σ) per square centimetre of boundary surface will be δ. The value of the numerical factor k will depend upon the actual displacement distribution of the electron spins as represented diagrammatically in Fig. 35 *b*. For the purposes of this investigation the value of k will be taken to be unity. The expression (31) shows that the stored energy in the boundary region due to the applied tensile stress is directly proportional to the thickness δ of the boundary.

From Hejsenberg's quantum mechanics investigations it is found that the work necessary to displace two neighbouring electron spins by the angle ϵ out of parallelism against the exchange forces is

$$\Delta\,\gamma_a=I\,\frac{1-\cos\epsilon}{2}$$

where I is the exchange integral for one pair of neighbouring atoms. If ϵ is small so that $\cos\epsilon=1-\epsilon^2/2$, then

$$\Delta\,\gamma_a=I\,\frac{\epsilon^2}{4}.$$

Observing that the assumption has already been made that the electron spin displacement is a function of the x co-ordinate only, there will be no angular spin between neighbouring atoms having the same x co-ordinate. Further, for two atoms which are adjacent in the Ox axis the distance between the electron spins will be the lattice constant a, so that the angular displacement between two such neighbouring spins will be

$$\frac{\pi}{\delta}\,a$$

since in the boundary width δ the total change of direction of the electron spins will be 180 deg., as shown in Fig. 35 *b*.

Now for each square centimetre of the boundary surface there will be

$$\frac{\delta}{a}\cdot\frac{1}{a}\cdot\frac{1}{a}=\frac{\delta}{a^3}$$

electron spins displaced by the angle ϵ from the neighbouring spin, so that in displacing the spins through the complete 180 deg. for each square centimetre of the boundary surface (*i.e.*, in the volume δ) the work done will be

$$\gamma_a=\Sigma\gamma\Delta\gamma_a=\frac{I}{4}\left(\frac{\pi}{\delta}a\right)^2\frac{\delta}{a^3}=\frac{\pi^2}{4}I\,\frac{1}{a\delta} \quad . \quad . \quad . \quad (32)$$

This expression (32) shows that the work done against the exchange forces is inversely proportional to the boundary thickness δ, whilst the expression (31) shows that the work done against the applied tensile stress is directly proportional to the boundary thickness δ.

Neglecting in the first place the numerical constants in the expressions (31) and (32), the total work done per square centimetre of boundary surface in establishing the boundary of thickness δ is

$$\gamma=\gamma_\sigma+\gamma_a=C\,.\,\delta+\frac{I}{a\,\delta} \quad . \quad . \quad . \quad . \quad (33)$$

The condition for stability is that this total energy γ must be a minimum, that is

$$\frac{d}{d\delta}\gamma=0,$$

from which it is found that

$$\delta=\sqrt{\frac{I}{C\,.\,a}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (34)$$

This result is shown diagrammatically in Fig. 36, from which it is seen that the minimum value of the total energy γ is obtained for that value of the boundary thickness δ, for which $\gamma_\sigma=\gamma_a$.

Instead of the exchange integral I for one pair

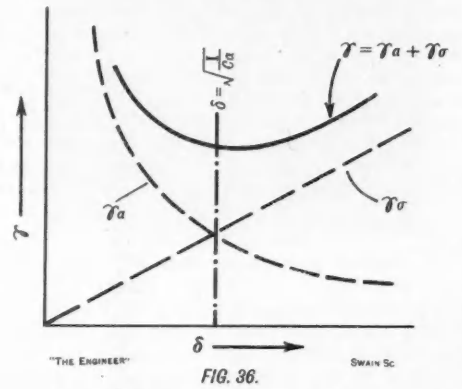


FIG. 36.

of atoms, the exchange integral A per cubic centimetre may be inserted in the expression where

$$A=\frac{I}{a^3}$$

so that,

$$\frac{\delta}{a}=\sqrt{\frac{A}{C}} \quad . \quad . \quad . \quad . \quad . \quad (35)$$

The energy factors A and C are approximately in the ratio of the Weiss internal field strength to the field strength necessary to magnetise the material to saturation, that is, approximately of the order of $10^6 : 10^2$, so that the boundary width δ will be approximately of the order of 100 times the lattice constant a. For small values of the tensile stress σ, however, C will be much smaller, and consequently the ratio $\frac{\delta}{a}$ may be very much greater than values of the order of 100.

If this value of $\frac{\delta}{a}$ be inserted in the expression (33) the total stored energy in the boundary between the two domains in Fig. 35 (*a*) is found to be

$$\gamma=2\,Ca\sqrt{\frac{A}{C}}=2\,a\sqrt{A\,.\,C}=2\frac{I}{a^2}\frac{a}{\delta} \quad . \quad (36)$$

The expression (36) shows how the total stored energy in the boundary diminishes as δ increases. If the boundary were to be reduced to the width corresponding to the distance between neighbouring electron spins—that is to say, the spins of neighbouring atoms were displaced by the full 180 deg.—then the stored energy would be

$$\gamma=2\,\frac{I}{a^2}$$

For various magnetic materials M. Kersten has given the following values for the order of magnitude of the boundary thickness δ, and the stored energy in the boundary γ respectively, viz.:

γ=0·1 to 10 ergs per square centimetre.
δ=30 to 3000 atoms.

A more rigorous investigation of the magnitude of δ and γ carried out by W. Döring leads, as it happens, to exactly the same result as that given in expression (35).

It is of interest to apply this result to a definite practical example. Thus, for a nickel-iron alloy (15 per cent. Ni : 85 per cent. Fe), the lattice is cubic space-centred, and the lattice constant a=2·7 Ångstrom units =2·7×10^{-8}cm.

[31] See also W. Döring, *loc. cit.*

The magneto-striction extension corresponding to magnetisation to saturation is

$$\lambda_s=25\times10^{-6}.$$

The applied tensile stress is

σ=65 kilos. per square millimetre=6·5×10^8 dynes per square centimetre.

The exchange integral is

$$2\,I=k\,.\,\Theta,$$

where Θ is the Curie temperature on the absolute scale and in this case is about 1000 deg. The constant k is Boltzman's constant and is given by

$$1\cdot37\times10^{-16}\text{ ergs per }1°.$$

The energy corresponding to the magneto-striction effect is

$$C=1\cdot5\,\lambda_s\,\sigma=245\times10^3\text{ ergs.}$$

From these data it is found that the total stored energy in the boundary between two neighbouring domains whose magnetisation axes are directly opposite is, according to Bloch, for the cubic spaced-centred lattice

$$\gamma=2\sqrt{\frac{2\,I\,C}{a}}=2\cdot23\text{ ergs per square centi-}$$

metre of the surface of the boundary. The value obtained experimentally by Sixtus was 2·7 ergs per square centimetre.

The width δ of the boundary as given by the expression (34) will then be

$$\frac{\delta}{a}=120;$$

that is to say,

$$\delta=120\text{ atoms wide.}$$

In practice the material will be subject to internal stresses which will vary from place to place, so that the characteristic quantities A and C will also vary, and consequently the domain boundary energy γ will vary from place to place. This variation of the stress will give rise to local "humps" of stress and the magnitude of the critical field H_c necessary to produce the Barkhausen jumps will depend on the length of such a stress hump in relation to the width of the domain boundary. Following Kondorski's determination of an expression for the minimal value of this critical field strength H_c, Kersten has given the following expression for the coercive force, viz.,

$$H_c=\frac{\lambda_s\sigma_i}{J_s}\,\frac{\frac{l}{\delta}}{1+\left(\frac{l}{\delta}\right)^2} \quad . \quad . \quad . \quad . \quad . \quad (37)$$

where l is the "wave length" of the internal pressure variations, and δ is the thickness of the boundary of the Weiss domain.

This expression will be a maximum when the ratio is equal to $\frac{l}{\delta}=1$, in which case,

$$(H_c)_{max.}=\frac{\lambda_s\sigma_i}{2\,J_s}$$

and gives the theoretical maximum value of the coercive force.

For nickel $J_s=480 : \lambda_s=36\times10^{-6}$. If σ_i=stress in dynes per square centimetre, that is

$$\sigma_i\text{ in kilos. per sq. mm.}=\frac{\sigma_i\text{ in dynes per sq. cm.}}{0\cdot981\times10^9}$$

that is

$$H_c=\frac{36}{960\times10^6}\,(\sigma_i\text{ in kilogrammes per square millimetre}\times0\cdot981\times10^8)$$

so that

$$H_c\text{ in oersted}=3\cdot7\,(\sigma_i\text{ in kilogrammes per millimetre}).$$

Measurements of the hysteresis loop for the recoverable electro-magnetic energy of a nickel wire which has been stressed to rupture in accordance with the expression (19) in § 9, show that in such a case the internal stress is approximately σ_i=10 kilos. per square millimetre. If this value for σ_i is inserted in the above expression the value of the coercive force=37 oersted, and this is actually about the value which is found from the hysteresis loop.

The formula (37) shows that the values of coercive force which have already been obtained in practice from the special alloys which have been produced for permanent magnets, viz., up to about 1000 oersted, are of the same order of magnitude which can be obtained from this expression when the reasonably appropriate values for the constants are inserted.

An expression can also be obtained for the minimum value for the coercive force by inserting $\sigma_i=\lambda_s E$, where E is Young's modulus, so that a guide as to the order of magnitude for the

minimum possible value of the coercive force is given by the expression

$$(H_c)_{min} = \frac{\lambda_s^2 E}{J_s} \frac{\frac{l}{\delta}}{1+\left(\frac{l}{\delta}\right)^2} \text{ oersted} \quad . \quad (38).$$

It is to be observed that it has not yet been found possible in practice to increase the ratio $\frac{l}{\delta}$ beyond certain limiting values.

This expression is found to be consistent with the low values of coercive force which have been found in certain alloys, such as perm-alloy.

(To be continued)

Scientific Instruments and Apparatus

No. II

(Continued from page 300, March 29th)

E. R. A.

THE British Electrical and Allied Industries Research Association was to have shown, among other things, the E.R.A. surge filter evolved by Messrs. R. H. Golde, W. G. Hawley, H. M. Lacey, and W. Nethercot. For many years the association has been making an intensive study of surge phenomena, directed particularly towards improving continuity of electrical supply during thunderstorms. In particular an investigation has been made of the operating characteristics of the various devices already available for the protection of sub-stations against surges, and attention has been paid to the possibility of an improved device and preferably a cheaper one.

Consideration of the problem led to the conclusion that improvement could be effected by combining the best features of a wave modifying device with those of a discharge device. At the outset a theoretical and experimental examination was made of the behaviour of inductance and resistance in parallel as a wave-modifier. In conjunction with the sub-station capacitance, an inductance produces considerable flattening of the wave front, but has the disadvantage that subsequently the peak voltage attained is much greater than that of the original wave. There is also a more or less violent oscillation after the peak voltage has been passed.

Resistance connected in parallel with the inductance has the effect of preventing this voltage overshoot and also of damping out the subsequent oscillation. But there is an optimum value for this resistance, too high a value failing to prevent oscillation and too low a value impairing the effectiveness of the inductance in flattening the wave front. In addition to studying the effect of resistance and inductance in parallel, an investigation was made of the behaviour of such a combination in conjunction with an air gap connected between the line side of the inductance and earth. Subsequently it was discovered that by using a special type of discharge gap, it was possible to combine the advantage of an inductance alone with that of an inductance and resistance in parallel. In Fig. 13 a diagram of the combination is shown. The inductance and

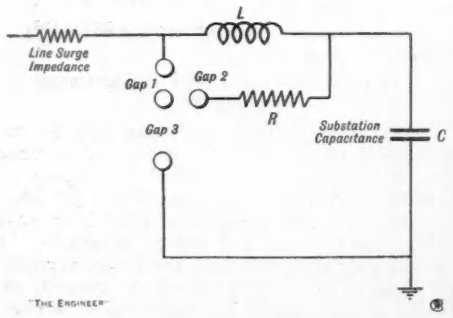


FIG. 13—E.R.A. SURGE FILTER COMPONENTS

resistance are indicated by the letters L and R respectively, while the sub-station to be protected is indicated by the capacitance C. The discharge gap consists of three parts numbered 1, 2, and 3.

The operation of the device may be described briefly as follows. On the arrival of a steep-fronted surge, a large voltage is set up across the inductance L and thus across the two gaps 1 and 2 in series. It causes these two gaps to flash over, thereby reducing the length of the total gap to earth to that of gap 3 only. Hence the third gap is caused to flash over, completing the discharge path to earth.

In the first stage of operation, *i.e.* before gaps 1 and 2 flash over, the inductance only is in circuit and consequently the maximum flattening of the incident wave is secured. At the same time, the building up of the voltage across the inductance causes very rapid breakdown of the two gaps 1 and 2, so that the total time for the complete breakdown to earth is appreciably less than it would be if the inductance and resistance were not present. Breakdown of the first two gaps puts the resistance in parallel with the inductance

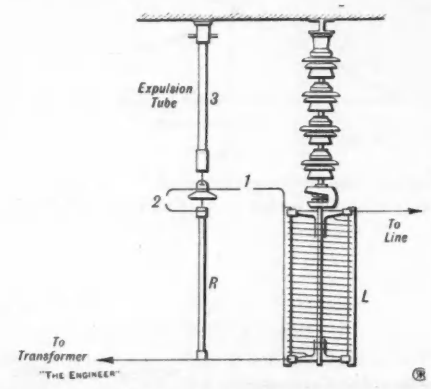


FIG. 14—E.R.A. SURGE FILTER

and so prevents both an overshoot of voltage and subsequent oscillation. Experiment has shown that the values of inductance and resistance which should be used are not critical. Tests have been made with values of inductance from 0·4 to 1 millihenry and with values of resistance varying from 500 ohms to 1000 ohms. As in the simple case first considered, there is an optimum value of inductance, but it has been shown experimentally that considerable departures from this value are permissible without interfering seriously with the performance of the apparatus. Experience has shown that it is definitely advantageous to use a rather higher value of resistance than that given by the formula for optimum resistance.

It is possible to secure interruption of follow current by using an expulsion gap, the external and internal portions of the gap corresponding to gaps 1 and 3 in Fig. 13. The gap 2 is not essential to the operation of the device, but is included to maintain the same total length of gap between either end of the inductance and earth. It has been shown experimentally that the inclusion of gap 2 has little effect on the behaviour of the device, while it does achieve its object in maintaining the general level of the system insulation.

In Fig. 14 is given a sketch of a model embodying the features described. The inductance L consists of a large air cored coil. The resistance R is wire wound on an insulating cylinder coated with waterproofing material. An expulsion tube has two external gaps corresponding to gaps 1 and 2 of Fig. 13. Oscillograms of typical results obtained with this model are shown in Fig. 16,

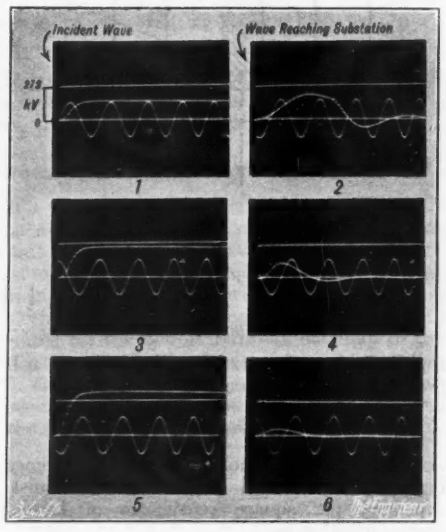


FIG. 16—TYPICAL OSCILLOGRAMS

The more severe the applied wave the better is the result obtained. The period of timing oscillation is 3 microseconds. When a wave of really high amplitude is applied to the device, the resultant wave left on the line is of negligible amplitude. On the other hand, when the amplitude of the applied wave is only just sufficient to cause the various gaps to spark over, there is little reduction in amplitude, although considerable flattening of the wave front is still obtained. It should be noted, however, that the amplitude of such a wave is not in itself sufficient to damage sub-station apparatus and that the flattening of the wave front which is obtained is sufficient to eliminate risk of damage caused by oscillations in inductive apparatus.

Another product of the British Electrical and Allied Industries Research Association, due to Mr. A. E. W. Austen, which would have been shown had the exhibition been held, was a differential amplifier with an oscillograph as a detector of

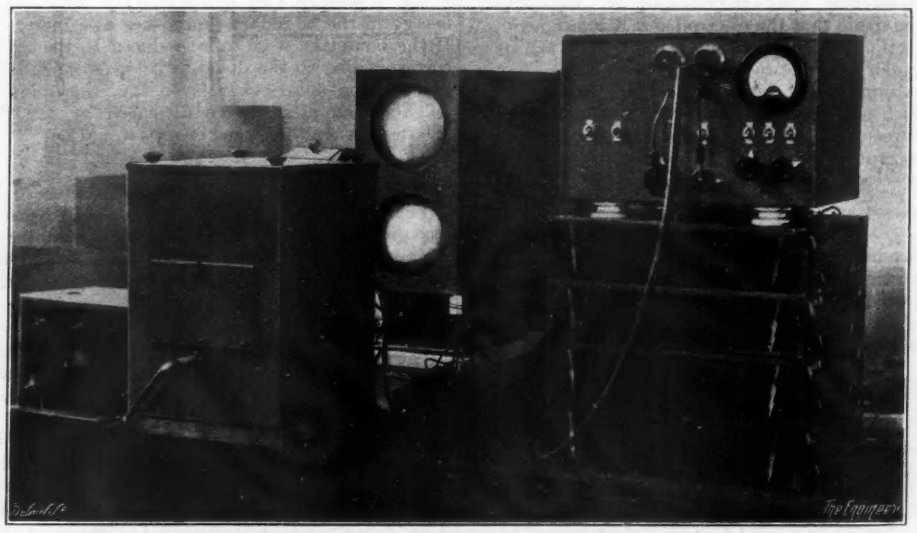


FIG. 15—DIFFERENTIAL AMPLIFIER AND OSCILLOGRAPH DETECTOR

discharges in insulation. The output of the differential amplifier with respect to earth is suitable for providing a supply to the deflecting plate of a sealed-off cathode ray oscillograph, proportional to the difference of potential between two input points which may be several orders of magnitude smaller than their common voltage with respect to earth. Primarily the amplifier was designed for uni-directional voltages and records are obtained on the drum camera shown on the left of Fig. 15, although for the purpose here described a stationary plate camera was used.

The amplifier, which employs the principle

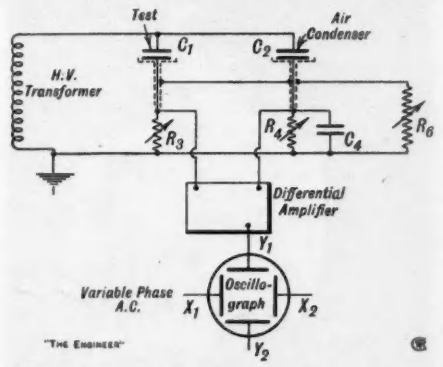
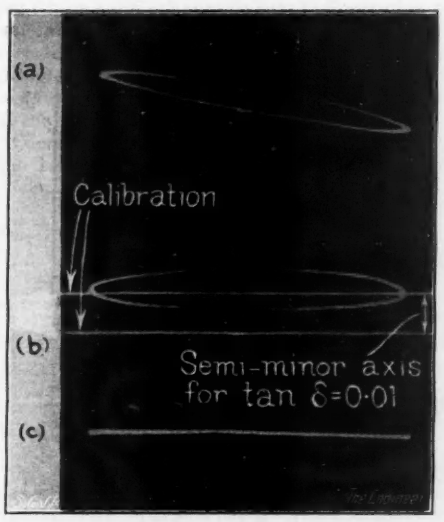


FIG. 17—H.V. SCHERING BRIDGE WITH OSCILLOGRAPH AS DETECTOR

described by Toennies,* has a substantially linear output over a range of 225 volts which, with an amplification of 2000, corresponds to an input swing of 0·1 volts. From D.C. up to 50 cycles A.C. a common potential with respect to earth of 5 volts produces a smaller output than an input between terminals of 1 mV. As has been described elsewhere,† such a device forms a very convenient bridge detector. In this case the amplifier was connected, as shown in Fig. 17, to the detector points of a H.V. 50 cycle Schering bridge, its output supplying the Y_1 plate of an oscillograph. The X_1 plate was connected to a supply of variable phase in parallel with the bridge source and when the phase is suitably adjusted, out of balance of the bridge, represented by the vertical



(*a*)—Both components unbalanced
(*b*)—Phase angle unbalanced only
(*c*)—Bridge balanced

FIG. 18—CONDITIONS OF BALANCE AND UNBALANCE

deflection, appears as a tilt ellipse when adjustment of the capacitative component is required and as a broadening of the ellipse for a phase angle out of balance, Fig. 18. The components may thus be balanced independently or, in the case of reasonably small phase angles and rough measurements, the phase angle component need not be balanced at all, its magnitude being obtained from the length of the vertical axis of the ellipse.

At stresses great enough to produce discharges in the test specimen, small discontinuities or kicks in the trace become visible. For photographic recording it is convenient to apply to the X_2 plate a voltage giving a vertical sweep, as shown in Fig. 19, in order to separate successive cycles. This method of investigation reveals a number of significant phenomena relating to the occurrence

* Review of Scientific Instruments, Vol. 9, No. 95, March (1939).

† H. W. Lamson, Review of Scientific Instruments, Vol. 9, No. 9.

of internal discharges which have been elucidated mathematically and with the aid of a model circuit in which a pair of thyratrons connected in opposition represented the discharge device. Typical records obtained with this model circuit at increasing voltages are shown in Fig. 20.

Still another device the association intended to exhibit is the apparatus, Fig. 21, for giving a direct method of determining the skin factor of a wire. The design of the apparatus is due to Mr. G. G. Sutton. Energy dissipation brought about by the passage of high frequency current through

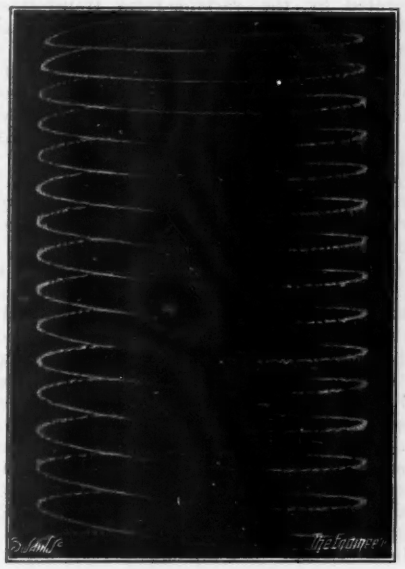
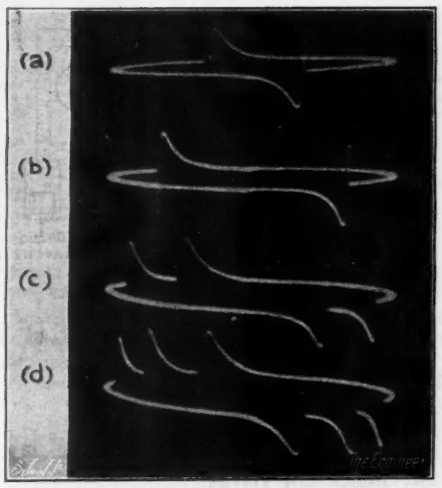


FIG. 19—RECORD OF VERTICAL SWEEP

two wires is made to expand gas surrounding the specimens and the increase in pressure in the enclosing glass chambers is communicated to manometers. One of the glass tubes contains a short length of Eureka wire, the high frequency properties of which are exactly calculable, thus enabling the apparatus to be calibrated by direct current. The other tube, which is in series with the first, contains the specimen to be tested for skin factor.

Owing to the short length of the tubes containing the wires and to the symmetrical lay-out of the apparatus, a reasonably high degree of equality in the currents of the two wires is achieved. In the apparatus illustrated, the glass envelope containing the wire is terminated at each end by a copper-glass seal to which the wire is electrically



(*a*)—Voltage just great enough to maintain discharges, 4·6kV
(*b*)—Voltage just great enough to initiate discharges, 6·3kV
(*c*)—Voltage just great enough to initiate 2 discharges per ½ cycle, 8·1kV
(*d*)—Voltage just great enough to initiate 3 discharges per ½ cycle, 10·1kV

FIG. 20—MODEL CIRCUIT WITH THYRATRONS AS DISCHARGE DEVICE

connected by soft soldering, thus facilitating the replacement of the specimen, the supply leads being connected in a like manner. The tubes are gas tight and thermal stability is achieved by immersion in an oil bath.

In making measurements, current is passed through the two tubes and the change in the difference between the levels of the nitro-benzene in the two limbs of the U-tube is noted in each case. From the direct current calibration curves for the two wires, the corresponding currents for equivalent displacements in the D.C. case may be found, and the skin factor is given by the ratio of the squares of these two currents. In dealing with ferro-magnetic specimens, the skin factor of

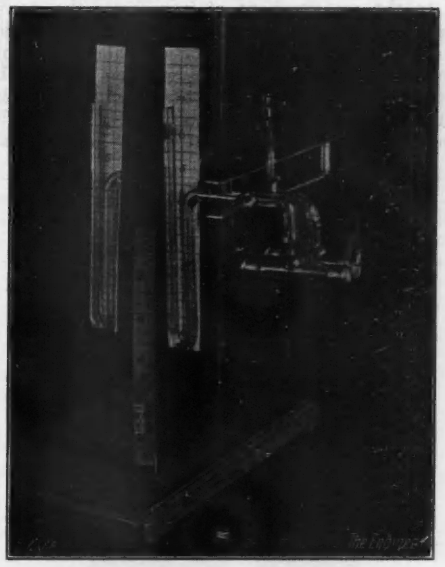


FIG. 21—WIRE SKIN FACTOR APPARATUS

the Eureka itself may be neglected, but with other specimens it must be taken into consideration and the above method of calculation modified.

The apparatus is designed for use with currents from 50 mA to 1 ampere at frequencies up to 100 MC but is being extended to frequencies up to

FIG. 22—WATTMETER—EVERETT EDGCUMBE

300 MC. The application of the method to the measurement of high frequency currents is apparent.

EVERETT EDGCUMBE AND CO., LTD.

The full scale deflection of a normal wattmeter usually corresponds to not less than about one-fifth of the product of the rated current and voltage, but for many purposes this sensitivity is nothing

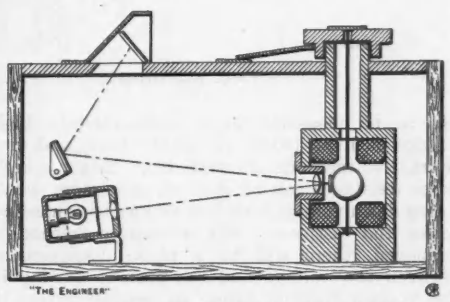


FIG. 23—SECTION THROUGH WATTMETER

like enough, and Everett Edgcumbe and Co., Ltd., have recently introduced an instrument in which this fraction is about $\frac{1}{200}$ or less. The instrument with the lid removed is shown in Fig. 22, whilst Fig. 23 is a section showing its internal construction. Operating on the electro-dynamic

principle, the moving element of the watt-meter carries a mirror by means of which a clearly defined line is projected upon a translucent scale plate, the moving element being suspended by a robust ligament from a torsion head carrying a pointer which moves over a long and evenly divided scale.

In the measurement of iron losses the power factor is extremely low and it is essential in order to prevent flux wave distortion that the ohmic resistance of the current winding should be negligible compared with the reactance of the magnetising circuit. In an Everett Edgcumbe instrument of this pattern giving a full scale

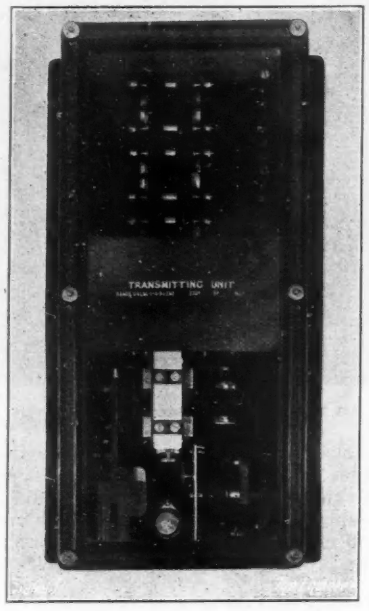


FIG. 24—TRANSMITTER—EVERETT EDGCUMBE

deflection with 2 watts at 50 volts the ohmic resistance of the current windings is only 0·05 ohms. The watt loss in the voltage circuit is also extremely small, amounting to only 0·15 watt at 50 volts, this being an important feature, for if desired the volt circuit may be connected across the terminals of the magnetising coil of the test circuit.

Another application of the instrument is the measurement of the watt loss in high voltage dielectrics and insulators. In this case the current is extremely small and is therefore passed through the moving coil of the wattmeter which thus forms the current element. In most cases the watt loss the instrument is the extremely small watt loss in the current element.

The Everett Edgcumbe auto-repeater system of distant indication has recently been substantially improved by the substitution of gas-filled relays for the previous electro-magnetic relays. The transmitter is shown in Fig. 24, and the connections in Fig. 25. In this particular case, the transmitting unit consists of a three-element megawatt meter A summating the outputs of three generators, the controlling force on this wattmeter being furnished by the permanent magnet moving-coil instrument B. The force is directly proportional to the current generated by the variable-ratio transformer C which feeds the moving coil through the rectifier D. The wattmeter carries a two-way contact E controlling the grid of one or other of the gas-filled relays F_1 and F_2, so that as soon as either contact is made the grid bias of one of these relays is neutralised, and a current flows to the respective Synclock motor G_1 and G_2.

In this way the gear wheel H is rotated in one or the other sense, thereby increasing or decreasing the current generated by the variable-ratio transformer C. The connections are so arranged that if the torque of the wattmeter A is greater than that of the moving coil B, the current through the latter tends to increase and vice versa. When the torques are equal both contacts at E are open and the variable-ratio transformer C remains stationary. In this way the current flowing in coil B is always exactly proportional to the torque exerted by the wattmeter element A, that is to say, to the megawatts to be transmitted. The current is led through pilots to direct indicating or graphic current receiving instruments which may be situated at any distance from the transmitting point.

In the case of the Fulham power station, where the system has been working for some years, it was decided to transmit the indications to the Bankside control room of the C.E.B., some six miles away. This was accomplished by means of a second " auto-repeater " which actuates a contact arm moving over a number of studs, each corresponding to a definite code, which is then transmitted over a Post Office line to Bankside, where it actuates a receiver scaled in megawatts.

The principal features of the system are :—(1) As there are only three moving parts the system is extremely simple ; (2) the absence of current carrying contacts ; the contacts at E merely supply voltage to the valve grids ; and (3) the use at the receiving end of moving coil indicating or graphic instruments of any desired pattern.

The extremely low values of illumination permitted under A.R.P. regulations has necessitated the design by Everett Edgcumbe and Co., Ltd.,

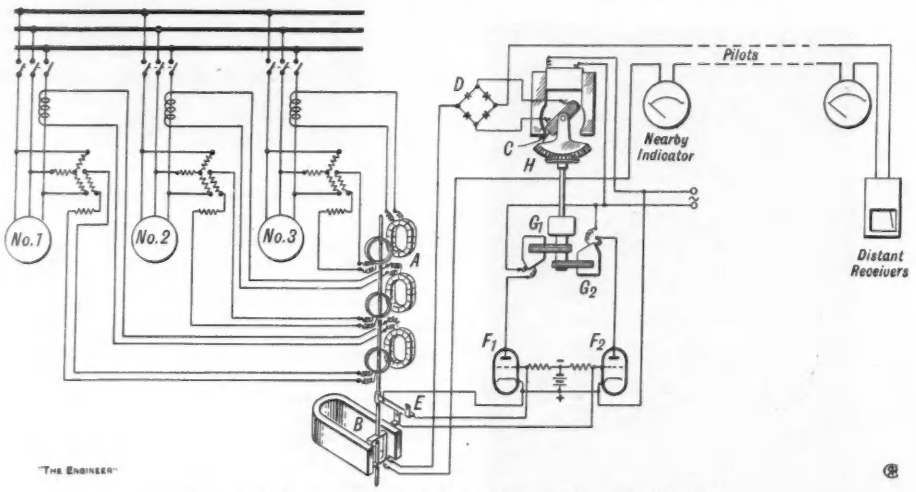


FIG. 25—CONNECTIONS FOR DISTANT INDICATION SYSTEM

has to be measured at a comparatively high voltage such as 10,000 or 22,000 volts, and two alternative methods are available. Either a high series resistance can be used or, as is more usual, a step-down voltage transformer may be connected across the testpiece. But whichever method is employed, there will be a phase displacement between the voltage and the current flowing in the voltage winding owing to residual errors in the step-down device used. For a correct measurement of the dielectric loss it is essential that this phase displacement should be reduced to zero. A variable compensating adjuster consisting of a condenser-shunted resistor can be embodied in the instrument covering an adjustment of from 10 minutes lag to 30 minutes lead. A feature of

towards the top part so that accurate readings are possible throughout the whole of each range. Various ranges are provided and are set by rotating a carrier which interposes a filter of the required transmission at the point F. The standard instrument has three ranges of 0·3, 0·003, and 0·0003 foot-candles, and satisfactory measurements are possible down to an illumination of 0·0002 foot-candle as prescribed for A.R.P. street lighting. If desired a fourth range of 3 foot-candles can be

FIG. 26—PHOTOMETER—EVERETT EDGCUMBE

added. The battery, rheostat, and voltmeter are contained in a neat walnut case, whilst for the complete equipment a leather carrying case with shoulder strap is supplied.

For certain purposes it may be sufficient to know that the illumination at a given spot is below a certain level without actually measuring it, and for this purpose an illumination gauge has been developed. Although this instrument is generally similar to the photometer it is considerably simplified, for the voltmeter and rheostat are

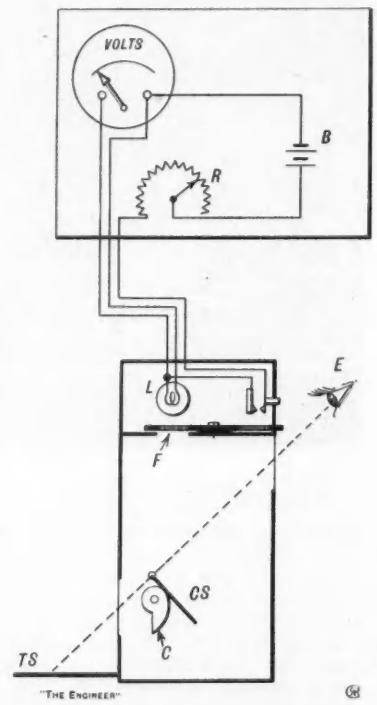


FIG. 27—DIAGRAM OF PHOTOMETER

of the new photometer shown in Figs. 26 and 27. It consists of a small polished walnut box with openings at opposite sides through which an eye E of the user views the test surface TS exposed to the illumination to be measured. Light from the standard lamp L falls on the internal comparison surface CS. A supply of current to the lamp is obtained from a dry battery B through a rheostat R which is adjusted until the pointer of the photometer stands at a red mark on the dial. A balance of the illumination between the test and comparison surfaces is made by varying the angle at which the light from the lamp L reaches the comparison surface by turning the cam C attached to an external milled knob. This cam is so shaped that the scale is very open over the lower part and closes up eliminated. The current taken by the lamp is so small that many thousands of measurements can be made without the fall in candle power causing an error of more than, say, plus or minus 5 per cent. The comparison surface is fixed in the case of the gauge and the setting of 0·02, 0·002, and 0·0002 is obtained by means of filters as mounted in the photometer. The dry battery is contained in a fibre case with shoulder strap and also carries the gauge for convenience in handling.

(To be continued)

Electricity as Applied to Metallurgy*

By A. P. M. FLEMING, D.Eng.

I WISH at once to say how much I appreciate the invitation to deliver the William Menelaus Memorial Lecture. The subject that has been chosen for this year's lecture covers a wide field and is susceptible to highly technical treatment. Upon inquiry as to the character of lecture most appropriate on this occasion, it was concluded that a general, rather than a technically specialised, lecture was most appropriate.

Applications of electricity to industry and, in fact, to every phase of human existence increase year by year and the metallurgical industry is no exception—in fact in certain phases of the metallurgical industry electric power has a more than usually significant application. It is fitting to say a word or two at this stage concerning the development of electric power and particularly to recall such important milestones in the history of its development as Galvani's famous frog-leg experiment in 1776, Volta's discovery that when two dissimilar metals are in contact with each other a current of electricity flows between them, and Oersted's recognition of some association between magnetism and electricity when he detected, in 1821, the agitation of a compass needle when placed in the vicinity of a wire carrying current. The next important step was the electric magnet made by Sturgeon, followed by the discovery of electro-magnetic induction by Michael Faraday in 1831. Digressing for a moment, we should also recall that Faraday laid down and proved the electrolytic law of the proportionality of current strength and its chemical action, and that the quantities of the various substances which are reduced from their combinations by the same current are proportional to their chemical equivalents. Upon this, Faraday based the measurement of current strength by chemical deposition.

It is, however, for his discovery of electro-magnetic induction that Faraday has become most famous. This discovery was of the most fundamental importance, and is the basis of the design of modern electrical generating and transforming plant. From the early small disc dynamo-electric machine made by Faraday, which is treasured in the Royal Institution and can be held comfortably in the hand, modern generators of a power capacity as high as over 130,000 H.P. have been developed to afford abundant supplies of electric power for all the multifarious applications known to-day.

Considering the applications to metallurgy, Fig. 1 gives a broad indication of the major uses

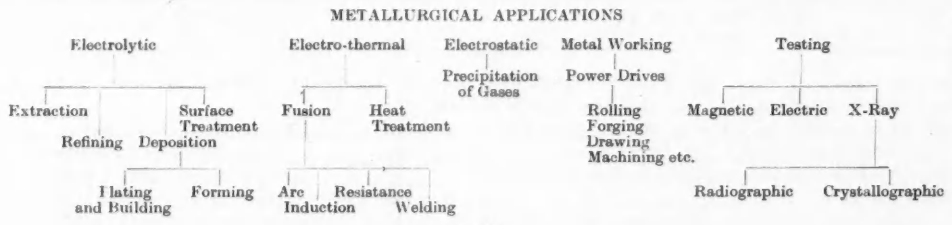


FIG. 1

which have been classified under the headings, electrolytic, electro-thermal, electrostatic, metal working, and testing. The first two of these are perhaps the most direct applications. Electrolytic processes include such operations as the extraction of metals from ores, the refining of impure metals, electro-deposition of a given metal on the surface of another with the object of providing a decorative finish or one which will be resistant to corrosion or abrasion, and anodic oxidation processes, the latter being so far confined mainly to the surface protection of aluminium and its alloys. Electro-thermal processes include numerous extraction and refining operations in the fields of ferrous and non-ferrous metallurgy, and also many different varieties of heat-treatment operation covering a wide range of metals and alloys. The various electric welding processes also come within this category. Some of the advantages of electric processing are: increased flexibility and greater purity of the final product; in furnace work, higher temperatures can be attained and temperature is more accurate, a large amount of energy can be liberated in a relatively confined space and can be applied just where required, whilst the inherent efficiency is frequently higher. Further, in some instances, *e.g.* extraction of aluminium, electrical methods have proved far superior, both economically and from the metallurgical point of view.

Electrolytic Processes

It was Faraday who suggested that the neutral molecules in an electrolyte consisted of two oppositely charged parts, which he called ions. Under the electrolytic effect, these oppositely charged parts dissociate, the positively charged ions travelling to the negative electrode and vice versa.

The historical development of electrolytic processes may conveniently be considered in three stages: the first dating from about 1800 to, say, 1836, covering the early experiments in decomposition of electrolytes and the discovery of the means of depositing certain metals. The second period from 1836–70, was marked by considerable developments in primary batteries, including the Daniell cell with its method of depolarisation, all of which provided stimulus for industrial development in the electro-deposition of metals. The third period from 1870 to the present time, embraces the contemporary development of dynamo-electric machinery to provide electrical energy on an unlimited scale. Electro-deposition was applied extensively, and electro-refining of metals from their ores proceeded on an ever expanding scale, notable examples being the deposition of chromium for protection against corrosion and tarnishing and electrolysis of fused salts for the production of metals such as aluminium, magnesium, sodium, calcium, and beryllium.

Fig. 2 broadly indicates electro-chemical processes of a metallurgical character as applied to-day. These are:—

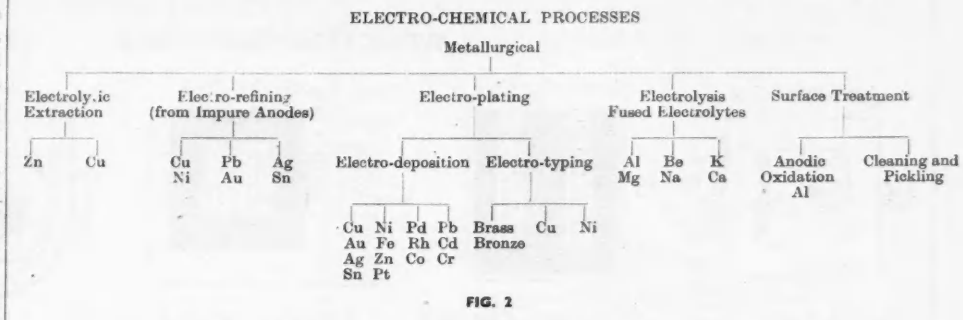


FIG. 2

Electrolytic extraction, which includes the recovery of metals such as zinc and copper from aqueous solutions.

Electro-refining, in which impure anodes of the crude metal are dissolved during the passage of current in a suitable electrolyte, and deposited in pure form on the cathode. Almost the whole of the world's output of copper is refined in this way and the same general method applied to numerous other metals.

Electro-plating, which is perhaps best known as a means of producing special metallic finishes, although it has other important applications such as the production of certain alloys from the constituent metals, and electro-typing and electro-forming, in both of which processes surface forms can be accurately reproduced.

Electrolysis of fused electrolytes, now widely applied for the extraction of certain metals, of which aluminium is a typical example.

Surface treatment, embracing all electrolytic cleaning and pickling processes and also the anodic oxidation process, the latter being applied to aluminium and its alloys to build up an artificial oxide skin for the purpose of improving corrosion resistance. Such oxide coatings can also be dyed to give coloured decorative finishes.

Some indication of the electricity required and the cost of electricity in the production of certain metals is tabulated in Table I, which also gives an indication of the cost of electricity in relation to the selling price of the product. The yield of a product per unit of electrical energy varies enormously from one product to another, *e.g.* the extraction of aluminium requires 9 kWh per lb., whereas in copper refining practice the power consumption is approximately 0·08 kWh per lb. A noteworthy point regarding cost is that the majority of electrolytic extraction and refining processes work on a 24-hour basis at steady load-factor, and it has also been possible to do something towards adapting certain electro-thermal operations to make use of off-peak periods in the power supply. Consequently, it is usually possible to obtain electrical energy for these processes at reasonably attractive rates.

Electro-Thermal Processes

During the past decade or so, very great progress has been made in the science of metallurgy. In ferrous metallurgy great improvements have been made in the quality of steels, both carbon and alloyed, and the demands in such fields as turbine construction and aero engine construction have put demands on the metallurgist for steels capable of withstanding increasingly arduous operating conditions. Such demands impose refinements in production, elimination of impurities, and scientific control of every process of melting and subsequent thermal treatment.

Fig. 4 indicates the ramifications of the applications of electricity in electro-thermal work. These applications may broadly be divided into those concerned with fusion and melting and those concerned with heat treatment processes. The three types of electric furnaces, namely, arc, induction, and resistance furnaces, each have their own fields of application. Various well-known forms of each type are illustrated diagrammatically in Fig. 3. The arc furnace was initially devised by Siemens, who demonstrated two methods, viz. direct arc heating, in which the furnace charge acts as one electrode, and indirect arc heating,

TABLE I.—*Electricity Required and Cost of Electricity in the Production of Certain Metals*

	Electricity required per ton, kWh	Cost of electricity, £ per ton	Approx. selling price, £ per ton	Electricity cost as per cent. of selling price
Ferro-manganese (75 per cent.)	3500	2·3	19	12·0
Ferro-silicon (45 per cent.)	4500	3·0	11	27·0
Ferro-tungsten (80–85 per cent.)...	8600	5·75	524	1·1
Ferro-chromium (6–8 per cent. Cent.) ...	7000	4·7	23	20·0
Aluminium	18,000	12·0	94	13·0
Magnesium:				
Electrolytic...	20,000	13·4	168	8·0
Electro-thermal	24,000	16·0	168	9·5
Sodium	15,000	10·0	—	—
Calcium	45,000	30·0	—	—
Beryllium	65,000	43·4	—	—
Copper (extraction)	2500	1·6	42	4·0
Copper (refining)	300	0·2	42	0·5

* The South Wales Institute of Engineers, Cardiff. The Thirteenth William Menelaus Memorial Lecture, March 19th, 1940. Abridged.

in which electrodes are arranged over the charge and an arc is struck between them. Stassano built the first furnace on the latter principle, and since that time both principles have been widely used by designers. Multiphase working was soon introduced, and it has proved possible to operate successfully arc furnaces capable of holding about 100 tons of steel, although it is usual in this country to adopt smaller units. In U.S.A., at the present time, there are in operation something like 700 furnaces, ranging between 1½ tons and 10 tons capacity. Many modifications have been tried embodying features such as hollow electrodes for water cooling, special electrode control arrangements, and designs to facilitate handling the molten charge, so that the diagram is merely a broad representation of some of the types developed. The limit of temperature of the electric furnace is that of the electric arc, about 3600 deg. Cent., whilst that practically attainable in the fuel-fired furnace is probably below 2000 deg. Cent.

The induction furnace employs the principle first shown by Faraday, and in the early types there was a laminated core having a primary winding fed from the electricity supply, whilst the secondary winding comprised an annular ring of refractory material embracing a limb of the laminated core and containing the metallic charge to be melted. The Ferranti furnace built about 1887 was the first of this type, and was followed by the Kjellin, the Rodenhauser, the Hiorth, and the Frick furnaces. At the present time the Ajax-Wyatt is the most widely used of the cored type furnaces.

Another type of induction furnace is that known as the coreless furnace, first built by Northrupp, and widely used to-day. In this the charge is placed in a crucible, which is in turn placed in a water-cooled inductor. The latter is supplied at high-frequency and the charge is melted by induced eddy-currents.

Regarding resistance furnaces, these are of various designs which differ mainly according to the way in which the furnace is to be used. They are suitable for temperatures up to a maximum of about 1100 deg. Cent., and the widest field of application is in connection with heat treatment processes, such as annealing, hardening, tempering, &c. The resistance heating principle is also applied in the case of salt bath furnaces also used in heat treatment work. It is interesting to note that the induction heating principle is now also being applied in this field, and lends itself to accuracy in the application of heat to specific areas of machined parts, &c.

The total connected load of all types of electric furnaces in the United Kingdom at the commencement of 1937 was estimated to be not less than 150,000 kW. In 1935 alone, plant exceeding 30,000 kW was ordered.

The production of steel by the electric method in the United Kingdom has increased steadily in recent years as shown in Table II, the output having practically trebled between 1930 and 1937 :—

Table II.—Production of Electric Steel in the U.K.

Year	Total production
1930	76,000
1931	53,300
1932	55,000
1933	74,900
1934	96,400
1935	106,800
1936	153,000
1937	215,000

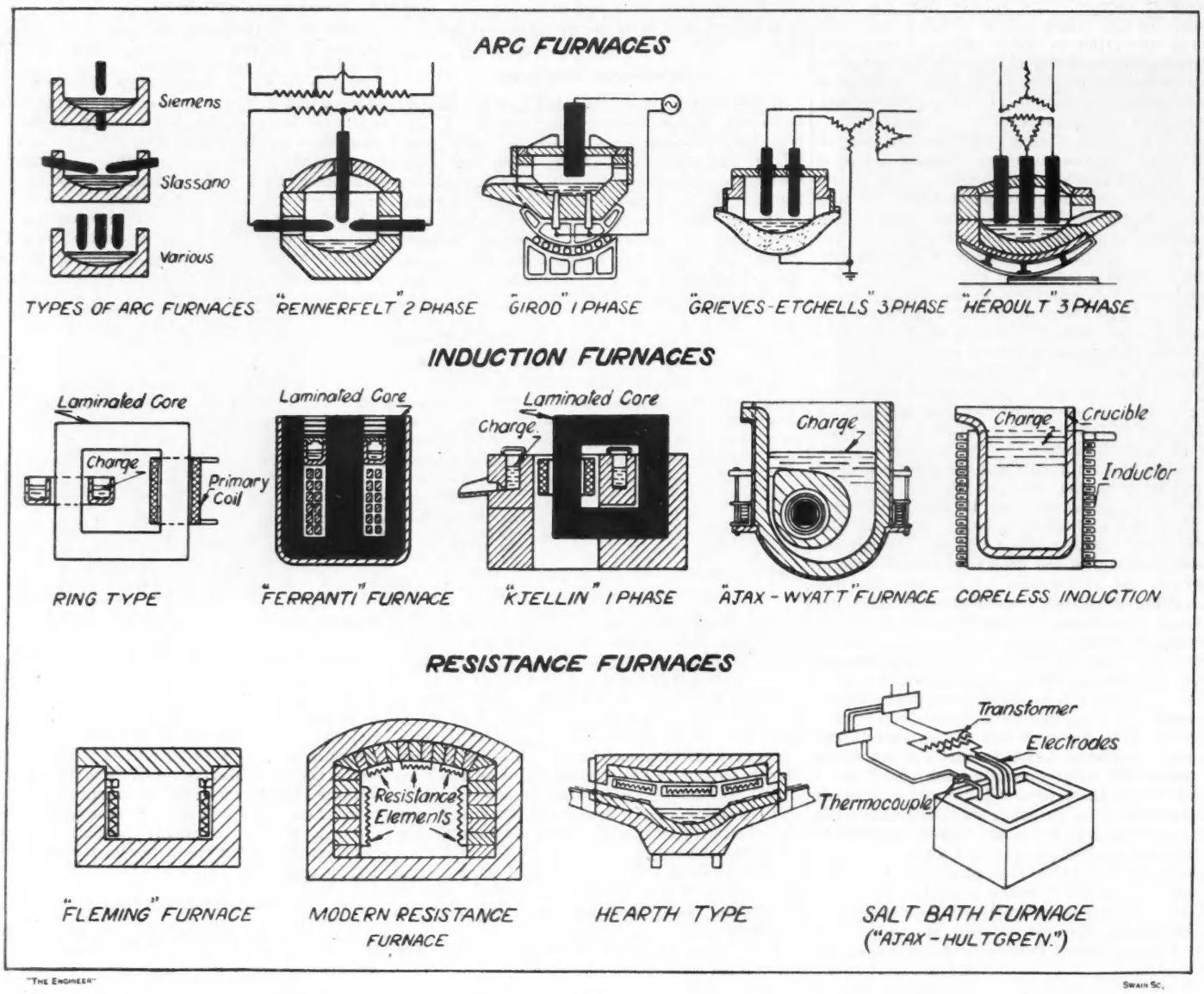


FIG. 3

ELECTRO-THERMAL APPLICATIONS

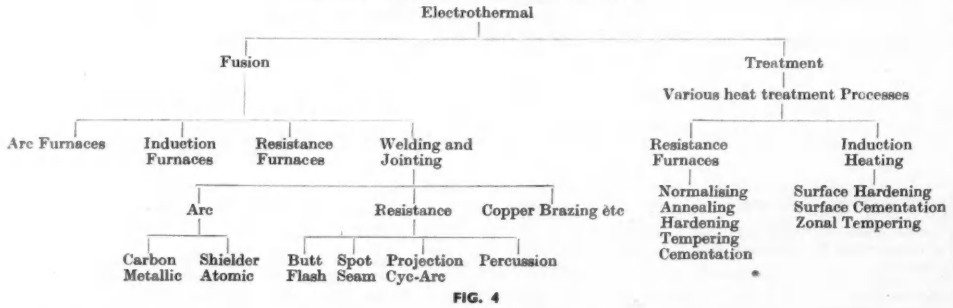


FIG. 4

Welding

Nowadays, consideration of the application of electricity to metallurgy would not be complete without reference to its use in the fusion of metals by welding. This process has become a most important factor in the fabrication of metal parts, not only in plant construction but also in place of riveting in structural work for buildings, and in the construction of bridges, ships, &c. An important advantage in connection with machine construction is the saving in weight and material which can be effected in this way, *e.g.* in the case of frames for electrical machines, structures can be produced with about half the weight of the corresponding cast structure, without loss of strength or rigidity.

One of the earliest methods of electric welding was that suggested by the experiment of Joule, who in 1856 welded iron wires together by burying them in charcoal and heating with electric current. In 1877, Elihu Thomson, while experimenting with an induction coil, found that on discharging a condenser through the fine wire secondary winding a bright flash appeared at the ends of the heavy wire primary coil which were in contact. These ends were found to be firmly welded

together. Based on this, Thomson built, in 1885, the first electric welding device, using a transformer to produce a relatively low secondary voltage which was applied to the pieces to be welded, the latter being held in contact by suitable clamps. This is the form of welding known as *resistance welding*, and is one still commonly used.

Arc welding processes followed the commercial introduction of the arc light in 1881. The heat metal from a filler rod is fused in when required. The gas also acts as a protective envelope resulting in strong, homogeneous welds.

In the case of resistance welding, the principal forms are butt, flash, spot, seam, and projection welding. In butt welding, the parts to be joined are butted together and contact maintained by pressure. On passing the electric current, heat generated at the contact renders the metal plastic, and the parts are then forced together, thus and are pressed against the other piece. The passage of current heats and welds these projections. Various modifications to these forms have been suggested from time to time, but are not in such wide use commercially.

Electrostatic Precipitation

An interesting and quite distinctive application of electricity in metallurgical work is the removal, by electrostatic precipitation, of solid particles

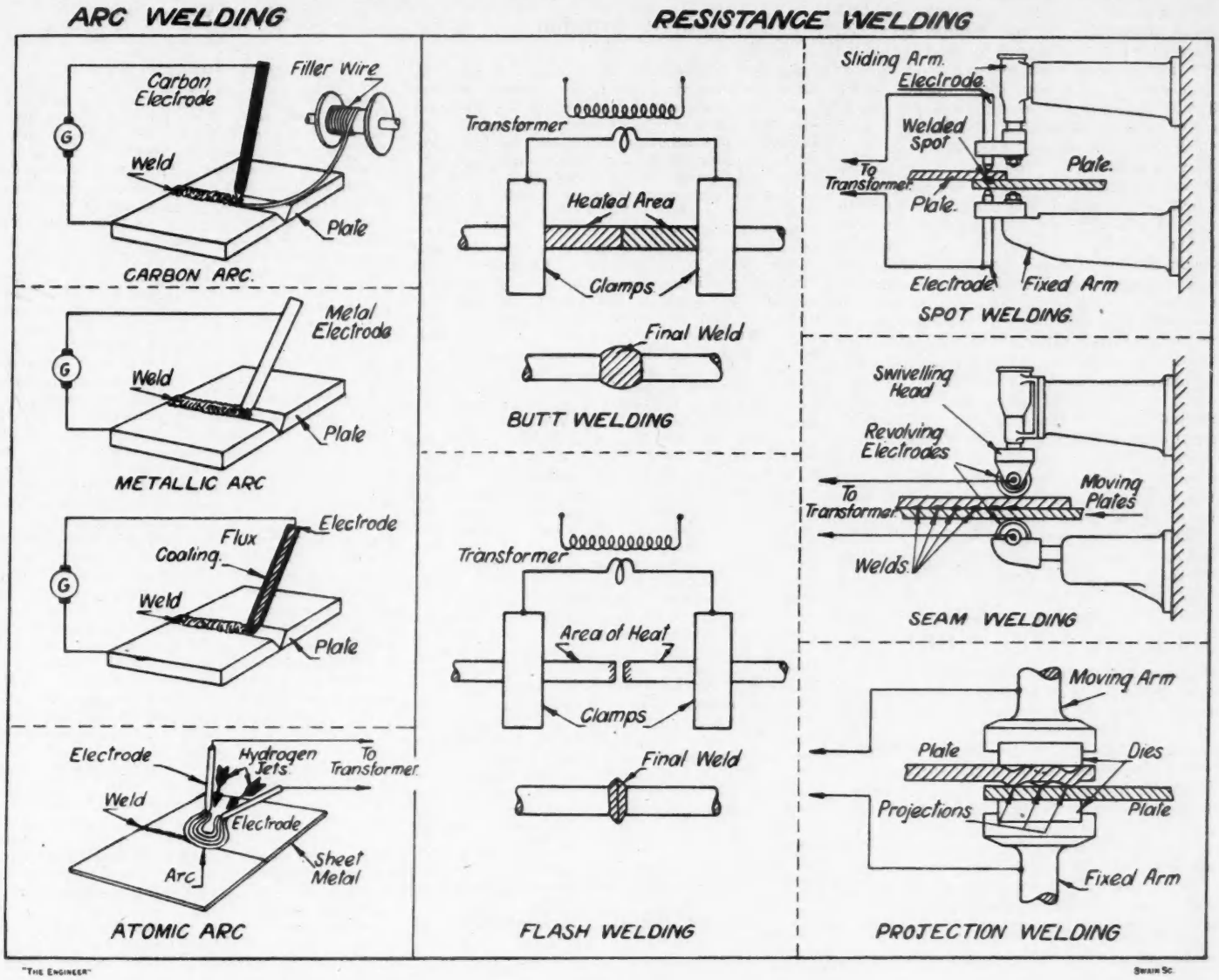


FIG. 5

of the carbon arc was blown by a jet of air on to the metal surfaces to be welded together, and later De Meritens substituted a single carbon as one electrode, the metal to be welded being the other. This process was further developed by Bernardos. The method has given way to the Slavianoff or metallic electrode process of arc welding, in which the melt-bar or welding rod is used as one electrode, the other being the material to be welded. Development of this process was retarded until the introduction of suitable fluxes to improve the characteristics of the weld, after which the process found wide commercial application. Usually the flux is mixed with a refractory coating as initially devised by Kjellberg, the action of the refractory being two-fold, namely, it permits the electro-magnetic effect of the welding current to act upon the molten metal, so rendering overhead welding possible, and it applies flux at a rate that adjusts itself perfectly to the melting away of the welding electrode.

Distinctive types of welding as applied at the present time are set forth diagrammatically in Fig. 5, which under "arc welding" not only illustrates the carbon arc and metallic arc processes, but also presents the atomic hydrogen arc process. This is a modern process comprising the use of two tungsten electrodes between which the arc is struck. Hydrogen gas is blown into the arc, the action of which, together with the catalytic action of the tungsten, dissociates the hydrogen molecules. Heat is thus absorbed from the arc and on recombination of the hydrogen atoms outside the arc zone, heat is liberated which far exceeds that obtainable by any other gas flame. The heat is used to fuse the metals and additional forming the weld. Flash welding is characterised by the parts being spaced a small distance apart, and the arc struck between them when current passes causes fusion temperature to be reached, and pressure is then applied. In spot welding, current is passed from one electrode to another through the material to be joined, a weld being formed at the point of application. Parts to be seam welded are placed between rotating discs forming the electrodes. Movement takes place in a series of steps, at each of which current is momentarily increased to a value necessary to raise the parts locally to the welding temperature, the weld being formed by mechanical pressure. In the projection welding process, projections are initially formed on one of the pieces to be joined, from gases produced from the roasting of ores and in blast furnaces. The gas is passed between two electrodes, one of which is maintained at a high D.C. voltage of the order of 30–100 kV. This electrode is maintained in a stable state of corona with the emission of electrons which bombard the gas molecules, to cause ionisation. The dust present clings to the ionised or charged particles and thereby becomes charged, and is attracted to the electrodes where it is neutralised and collected.

TABLE III.—*Power Drives*

Industry	1924			1930		
	Power Applied mechanically H.P.	Power Applied electrically H.P.	Electrification per cent.	Power Applied mechanically H.P.	Power Applied electrically H.P.	Electrification per cent.
Metalliferous mines and quarries	53,360	45,857	46·2	33,433	37,817	53·1
Smelting, rolling and founding of iron and steel and blast furnaces	1,378,638	1,039,759	43·0	1,404,040	1,319,937	48·4
Extracting and refining of copper and brass	20,133	90,265	81·6	14,797	118,732	88·9
Extracting and refining of other non-ferrous metals	8432	55,982	87·0	6237	82,802	93·1
Gold and silver refining	332	4966	93·7	271	9270	98·2
Tinplate	86,725	15,855	15·5	79,015	38,057	32·5
Finished brass	9301	17,867	65·8	5706	24,218	80·5
Wrought iron and steel tubes	16,933	84,157	83·3	13,499	112,460	89·2
Anchor chains, nails, bolts, nuts, screws, and rivets	15,282	32,311	68·0	18,487	77,921	80·9
Wire	23,276	71,744	75·5	16,292	86,694	84·1

Power Drives

There is little need to emphasise the significance of the application of electrical power as a driving and handling means in a large variety of metallur-

gical operations, such as rolling, drawing, forging, machining, &c. Table III indicates the importance of electrical power applied for such purposes in metallurgical and associated industries. These figures are derived from the 1924 and 1930 census of production, and illustrate the remarkable extent to which electric drive has been applied in many cases.

Testing

A most important application of electricity in metallurgical work arises in connection with methods of testing. In this respect, electricity has proved an invaluable aid to the metallurgist in fine measurement and researches, as well as for the purpose of checking the quality of his materials. Broadly, the methods afforded can be classified as magnetic, electric, and X-ray, in each of which there are various forms.

Using standardised specimens whose composition and heat treatment are known, comparisons may be made of unknown specimens by magnetic testing. By suitable exploration of the magnetic behaviour of the specimen in an alternating magnetic field it is possible to relate the phase and quadrature components of the voltage induced in a search coil and by comparing these with the standardised specimen certain inferences can be drawn as to the composition of the material without the need for destruction of the specimen under test. Magnetic methods have also been developed for fault detection, and have been of increasing importance, due to the tendency to cut down material costs and weight while still maintaining the safety factor by more rigid inspection and care in production. The presence of a fault or change in magnetic composition can be detected by the distortion these cause in the magnetic field, the distortion being located either by a direction indicator such as a magnetic needle or by a moving search coil. Another and most valuable method, however, is that developed largely by the Metropolitan-Vickers Company in which the specimen is magnetised and then subjected to examination under a coating of liquid containing very finely divided magnetic particles. Thus when examining bar material for longitudinal cracks a heavy current is passed down the bar while it is immersed in a bath of finely divided magnetic particles suspended in a light oil. The particles, which can be black or red so as to contrast well with any surface colour or finish, form sharply defined lines to indicate the flaws. Surface cracks that cannot be detected by the naked eye or even by considerable magnification are readily shown up, and by controlling the direction of the flux cracks in any direction can be revealed. This method is of growing importance and is perhaps the most effective means to-day of checking this form of weakness in metals.

Electrical methods of fault detection have also been developed. Comparative conductivity tests enable the soundness of metals to be assessed whether they are magnetic or not, *e.g.* much can be learned about the internal condition of a welded joint by passing direct current across the weld and measuring the P.D. across the weld at various points along its length by means of a millivoltmeter. Local increase in resistance, and so in all probability a reduction in effective section, is thus determined.

X-rays have been applied in two distinct directions, namely to assist the study of the crystal structure of materials, and to reveal the presence of flaws.

Present X-ray methods enable the lattice pattern of any metal or alloy to be ascertained. Each metal has its own distinctive lattice by which it may be recognised, and the distances between the atoms of the lattice can also be determined with very great precision.

Moreover, the X-ray structure of a metal or alloy is modified in a marked manner by heat-treatment and cold working operations and may therefore be used to investigate the physical state of the material. This aspect of crystallography is of great value in dealing with the directional properties produced by such operations as rolling and wire-drawing. (Much work has also been done on the effect of fatigue on the structure of metals.)

On the academic side our knowledge of such matters as equilibrium diagrams, precipitation phenomena, and age-hardening have been profoundly extended by the use of X-ray methods.

Matter is relatively transparent to X-rays of low-wavelength and it is not surprising, therefore, that this property has been used to examine metallic objects for the presence of flaws, holes, &c. This relatively new method of testing, which is, of course, non-destructive, has become very important, particularly in the examination of light alloy castings—highly stressed light alloy castings for use in aeroplane construction are all examined by this method. The method is also used extensively in the routine examination of welded structures and has led to a steady improvement in welding technique.

Civil Aviation

Sir Kingsley Wood, the Secretary of State for Air, and officials of the Air Ministry, recently received representatives of the independent air line operators, when the question of civil aviation in wartime was discussed. Sir Kingsley Wood said he had given careful consideration to the memorandum and statements put forward by the deputation. He was obliged, however, to have regard to wider considerations of our war effort and the best use of our resources of aircraft and personnel. In view of our military requirements, immediate and future, and in particular of the responsibility of the Air Ministry to the Army for providing aircraft for Army co-operation work it was imperative that much of the work that had so far been carried out by the civil companies should in future be performed by the Air Force itself. For this purpose a large and increasing number of aircraft were required, amongst which were those civil types which had hitherto been engaged under civil contracts to carry out the task. The Air Ministry would pay a fair and reasonable price for the aircraft on the basis of a report made by an independent authority. He felt there should be little difficulty so far as the personnel were concerned in view of the need of the R.A.F. for technical and skilled personnel, and the considerable requirements of the aircraft industry. As to the suggestion that aircraft were being requisitioned in a manner that showed favour to the companies associated with the railways, Sir Kingsley Wood said that this was not so. It was only possible to justify the retention of internal air lines in war where some national interest was involved, and this principle was being interpreted broadly as applying to routes crossing water with no alternative means of land transport, such as the lines connecting England with Belfast, certain places in Scotland, and the Channel Islands. The companies which were previously licensed on these routes had naturally been selected to continue where they had operated in peacetime, and any other basis would be unfair. The companies which were operating those routes were in fact also having more than half their aircraft requisitioned, and were only being permitted to retain the bare minimum necessary for running the selected routes.

Water Supply Research

The Department of Scientific and Industrial Research has opened a new Water Pollution Research Laboratory at Watford equipped for work on the problems of water supply, sanitation, and the recovery and utilisation of valuable materials from trade effluents of many kinds. On the outbreak of war plans for building a special research station for work of this nature, which is carried out under the general guidance of the Department's Water Pollution Research Board, were well advanced, but it was decided to postpone them and to secure temporary accommodation to meet the immediate needs of the work, which are likely to increase under war conditions. Suitable premises have been obtained and inquiries and other communications intended for the Director of Water Pollution Research should henceforth be addressed to the Water Pollution Research Laboratory, Langley Road, Watford, Hertfordshire. The staff of the laboratory, in co-operation with the Building Research Station, has already been largely responsible for designing improved and less costly sanitary equipment for air raid shelters. Although no central research station has hitherto been available for the work of the Water Pollution Research Board arrangements have been made for many investigations to be carried out in the last few years on behalf of the Board in other laboratories, which have led to important results. It has been shown, for example, that by treatment of certain clays and glauconitic sands found in this country materials can be obtained which are equal to minerals now imported from abroad, for use in softening hard water. It has also been discovered that certain synthetic resins can be used to remove dissolved salts and other substances from water. This discovery, the importance of which has been recognised throughout the world, is being used not only in softening water, and in the production of water containing little or no dissolved substances, but also in the recovery of valuable materials, such as copper, from waste waters containing them. Another important investigation was that on the effect of the discharge of sewage into the estuary of the River Mersey on the deposition of silt and other solid matter in the estuary. This investigation, which was made at the request of local interests, who met the whole cost of the work, was successful in settling a controversy of long standing. The issues involved included the conservancy of the river and the future of the estuary for navigation, and questions of installing works likely to cost several million pounds sterling for treating the sewage from a population of about 1½ million.

Sixty Years Ago

Steel, Then and Now

Inspired by a recent discussion at the Institution of Naval Architects, we sought in a leading article in our issue of April 2nd, 1880, to indicate the nature of the steel which would be made in large quantities within the next few years. Two parties were at that time dividing the field between them on this subject. One body of opinion held that steel would continue to become stronger and stronger and that within half a dozen years or so specifications would call for steel plates having a tensile strength of not less than 35 tons per square inch. The opposition group argued that it was impossible to produce steel with such a high strength which at the same time would be really ductile and further that even if it could be produced it would be unnecessary to do so. Those who argued thus contended that all attempts to rivet steel plates with steel rivets had proved disappointing, unless the rivets were made of the very mildest steel, and that no riveted seam using steel plates and steel rivets could be made which would have a greater tensile strength than 19 tons per square inch of the plate section. If iron rivets were used the attainment of equal strength in the seam and the plates required that the sectional area of the rivets should be about 20 per cent. greater than the sectional area of either of the plates. To provide such a rivet area would seriously weaken the plate by the removal of material from it. Hence it was argued that so long as the seams in riveted work limited the strength that could be obtained it was unnecessary to use steel plates possessing a greater strength than about 28 tons per square inch. Any strength in the plates beyond that figure could not be utilised, and if it could only be realised by decreasing the ductility of the steel the increased strength in addition to being useless would be a source of liability rather than of any advantage. We gave general support to this argument but pointed out that it might cease to be valid if, as was not impossible, welding took the place of riveting or if boiler rings—"as much as 14ft. in diameter, 8ft. or 9ft. wide and an inch thick"—were ever rolled from the solid as they might yet be as readily as a 7-foot locomotive tire. The steel of the future, we asserted, would be a ductile, thoroughly trustworthy, material with a tensile strength not exceeding 30 tons. Only two developments, neither of which was likely to occur immediately, would cause us to depart from the conclusion; either the abandonment of ductility as an essential criterion on the part of steel users or the combination by the steel makers in the one steel of high ductility and high strength. . . . After sixty years of experience in the use of steel there is little to add to what was said in this leading article except to support the views expressed in it. The B.S.I. specification for structural steel for bridges and buildings lays it down that the material shall have a strength lying between 28 and 33 tons, the rivet material having a breaking strength of between 25 and 30 tons. These figures relate to ordinary mild steel. Engineers have not abandoned their insistence upon ductility in steel. The specification referred to requires it to be at least 20 per cent. for the plates, &c., and 25 per cent. for the rivet material. The other development which we mentioned has, however, come to pass. The steel makers have succeeded in producing a "high tensile" steel which possesses good ductility. This material, as recognised by the B.S.I., has a strength lying between 37 and 43 tons, with an elongation of not less than 18 per cent. The rivet material to be used in conjunction with this steel is required to have a strength of between 30 and 35 tons, and an elongation of at least 22 per cent.

Long Piles for an American Bridge.—An article in *Engineering News Record* describing the foundation of a two miles long bridge over the Potomac River to Ludlow Ferry gives particulars of some specially long piles which are being driven. It is stated that more than 37 miles of steel H-section piles, up to 194ft. long, are being driven for the piers. These piles, which are thought to be the longest of their type ever driven, weigh up to 12 tons each, and are driven with their tops as deep as 80ft. below the surface of the water. They are driven by a special 16-ton steam hammer having a 7-ton ram mounted on a floating pile driver which is equipped with 90ft. telescoping leads. The piles were arranged in position at the river bed by means of a template in which rectangular guide holes had been cut. This template consisted of a wooden platform, sunk to the river bottom, and fastened on wooden piles driven previously and cut off to a set height above the level of the bed.

Rail and Road

ROAD VEHICLES—NEW REGISTRATIONS.—The number of mechanically propelled road vehicles registered for the first time in Great Britain during the month of February, 1940, was 9090, compared with 33,907 in February, 1939.

OIL FIRED LOCOMOTIVES IN EGYPT.—It has been decided to convert a number of coal burning locomotives on the Egyptian State Railways for heavy oil fuel owing to the anticipated difficulty in obtaining imported coal. If the experiment is successful, it is expected that further engines will be converted.

NEW RAILWAY IN CHINA.—A note in the *Railway Gazette* says that it is reported that a contract has been signed for a French loan of 480 million francs to the Chungking Government for the construction of a 720 kilometres line from Kunming to Suifu. It would appear that this line will be an extension of the French Yunnan railway which connects Hanoi and Kunming. Suifu is on the Yangtze river not far above Chungking.

SLOANE SQUARE UNDERGROUND STATION IMPROVEMENTS.—On Wednesday, March 27th, the first step in the reconstruction of Sloane Square underground station was completed with the opening to the public of the escalators from the platforms to the street, and a new ticket hall. This is the first time that the London Passenger Transport Board has built escalators directly down on to an open platform. These escalators are only for ascending passengers and are 50ft. long, rising 25ft.

WELDED RAILWAY BRIDGE IN LONDON.—The second all welded railway bridge to be placed in service in this country has been opened to traffic at Hainault in Essex by the London Passenger Transport Board. It has a clear span of 40ft. between the faces of the abutments, the main girders being over 50ft. long. It has been designed for a maximum stress of 8 tons per square inch in tension and the saving in weight as compared with a similar riveted structure is about 20 per cent.

TRAFFIC LIGHTS.—A new design of traffic light which has been approved by the Home Office will be brighter by day than by night and will, it is hoped, overcome the present difficulty of seeing the screened lights in bright sunlight. Instead of the cross masks at present in use, the whole of the top half of the red, green, and amber lamps of the new lights will be visible. In order to comply with the black-out restrictions the lights, which will be bright during the day, will be operated on less power at night.

PROPOSED NEW RAILWAY IN TURKEY.—The monthly trade journal of the British Chamber of Commerce in Turkey says that there is under consideration a scheme for a new railway which will connect Istanbul with the Black Sea through Ada Bazar, Duzdje, Bolu, Gerede, and Ismet Pacha. From Bolu a new line will be constructed to Ankara. The conversion of the narrow gauge line from Erzerum to Kars to standard gauge is also contemplated. This line is the connecting link between the Russian and Turkish railway systems.

NEW ELECTRIC LOCOMOTIVES FOR BRAZIL.—The General Electric Company of America recently shipped to Brazil four large new 2–C C–2 electric locomotives to work between Jundiahy and Rincao, and later between Ityrapina and Bauru when the lines have been electrified. The new locomotives have a continuous rating of 4050 H.P., while their rated performance on an hauling basis is 4470 H.P. They have an overall length of 75ft. the wheel base being 66ft. Of the total weight of 364,000 lb., 270,000 lb. is on the driving wheels. Designed for a maximum speed of 90 m.p.h. the locomotives have a tractive effort of 30,000 lb.

NEW ELECTRIC LOCOMOTIVES IN SWEDEN.—Three new electric locomotives ordered by the Swedish Railways from the ASEA Company are to be of a new type. According to *The Electrician* the new engines will have four pairs of drivers of the same diameter as the older types (1350 mm.), but each pair will be driven separately by the four motors. The weight of each engine is about 100 tons and the power output in the region of 3500 H.P. for a maximum speed of 85 m.p.h. According to the contract stipulations, the new type engine is to be capable of hauling a 600-ton train from Gothenburg to Stockholm (456 km.) in 290 minutes with stops at nine intermediate stations, which requires the line to be reinforced for a speed of 75 m.p.h.; similar requirements also apply to the lines Stockholm–Malmo and Stockholm–Uppsala.

MODERNISATION OF A SWISS RACK RAILWAY.—Three modern lightweight motor-coaches recently introduced by the Bex–Gryon–Chesieres Railway, a metre-gauge line connecting with the Swiss Federal system at Bex, on the Simplon main line, are described in a note in the Electric Railway Traction Supplement of the *Railway Gazette*. In conjunction with improved operating methods, these coaches have enabled a faster and more frequent service to be provided. The cars have a tare weight of 17¼ tons and have two 125 H.P. motors. Mixed rack and adhesion equipment is fitted and up the 1 in 4 rack section a speed of 9·3 m.p.h. can be maintained; on the adhesion section the normal top speed is 18·6 m.p.h. A reduction in overall journey time from 78 to 45 minutes has been made possible by the new stock.

THE NIAGARA FALLS BRIDGE.—Tenders have been received by the Niagara Falls Bridge Commission for the construction of the proposed four million dollar Rainbow bridge over the Niagara River. The bids are being taken on the basis of both concrete and steel approach spans and the Commission is to decide which of the two types will be adopted. The bridge, upon which construction will begin early in April, will be a high level single span ribbed type steel arch bridge having a clear span of 960ft., and a clearance of 217ft. between mean water level and the crown of the bridge. It will accommodate four lanes of traffic on two roadways 22ft. wide, separated by a 4ft. wide raised strip. On the south side a 10ft. wide footpath will be provided, and this will be separated from the road by a solid guard rail. The bridge and its approaches will be about 20ft. higher than the old Falls View bridge which collapsed on January 27th, 1938, during an unprecedented ice jam.

Miscellanea

RESEARCH IN INDIA.—In the next budget, the Indian Government is to provide £37,500 for a Board of Scientific and Industrial Research.

SOUTH AFRICAN STEEL PRODUCTION.—The present annual capacity of 340,000 ingot tons of the South African Iron and Steel Corporation works at Pretoria is being extended to a capacity of 440,000 tons a year.

MINE EXPLOSION.—Early on Thursday, March 21st, an underground explosion at Mossfield Colliery, Adderley Green, Longton, near Stoke-on-Trent, caused the death of eight men, and four others were seriously injured.

THE HONDA PRIZE.—The Honda Prize—a gold cup and a sum of money—has been awarded to Sir Harold Carpenter, Professor of Metallurgy in the Royal School of Mines, by the Japanese Metallurgy Society. This is the first occasion on which the prize has been awarded to a foreigner.

NEW ORDNANCE FACTORIES.—It has been announced by the Minister of Supply that thirty-seven more Royal Ordnance factories are being planned and most of them will be in production by next year. He said that nine such factories were open at the outbreak of war and that there are now sixteen in operation.

EXHIBITION OF MUNITION SAMPLES.—The Ministry of Supply announces that the exhibition of munition samples, London and South Eastern Area, has been moved from Savoy Hill House to 111, Penfold Street, Paddington. Applications for permits to view this exhibition should be made to the Area Officer, Ministry of Supply, whose present address is Savoy Hill House, London, W.C.2.

MERCURY PRODUCTION IN CHINA.—According to reports of the United States Chamber of Commerce the Kweichow Mining Administration, jointly controlled by the National Resources Commission, and the Kweichow Provincial Government, has been authorised to increase its capital from 600,000 to 2,000,000 yuan in order to increase the company's production of mercury to 500 tons per annum. Present production is less than 100 tons.

A LARGE TESTING MACHINE.—A large testing machine said to be the biggest of its kind, has been installed by the Aluminium Company of America. It is capable of exerting a force of three million pounds in compression, and one million pounds in tension. It has an overall height of over 40ft., its width being over 16ft., and its depth 9ft. For compression testing a maximum height of 186in. is available and for tension testing 150in. plus a 36in. stroke, and the machine can exert its maximum force at speeds up to 36in. per minute. The machine can also be operated as an extrusion, forging, or forming press.

WARTIME FUEL SUBSTITUTES.—In the course of a statement with regard to home produced substitutes for imported fuels, the Secretary of Mines recently told the House of Commons that he had received an interim report on the recovery of benzole from one of the committees which had been formed to investigate the subject. The report indicated that already additional crude benzole is being recovered at an estimated rate of 15 million gallons a year, and an extension of the voluntary effort should secure a further 12 million gallons per annum. Another survey showed that this country's production of tar, creosote, and pitch can take the place of imported fuel and bitumen to the extent of 300,000 tons in the current year.

SMALL PERMANENT MAGNETS.—A note in the *Electrical Review* describes a method which has been developed by the General Electric Company of America for the manufacture of permanent magnets which are too small for economic production by casting. These magnets are made from powdered "Alnico," a nickel aluminium compound, and can be produced in sizes from 0·2 to about 0·005 oz. in weight. The powder is first preformed in a tablet making machine, and the forms are then placed in small moulds for their transport through the hot zone of a sintering furnace whence they pass into an extension zone where cooling is so controlled as to ensure optimum qualities. It is stated that small magnets made in this way can be mounted with the aid of soft solder and the usual zinc chloride solution flux, after preliminary removal of aluminium from the surface by etching. Similarly, iron pole faces can be attached, while pins or sleeves inset in the pressed mixture will be anchored by shrinkage during the sintering. Iron powder deposited on top of the powdered "Alnico" mixture in the mould prior to pressing provides a backing which can be drilled and tapped, but this method of mounting can only be utilised when partial shunting will not occur.

EFFECT OF LEAD IN PETROL ON CRANKCASE OILS.—The results of researches carried out in the United States by the Ethyl Gasoline Corporation on the effect of lead on crankcase oil are given in an abstract in the Journal of the Institution of Automobile Engineers. It is pointed out that where lead treated fuels are used oil drained from the crankcases of motor-cars is found to contain approximately 0·50 per cent. by weight of lead in the inorganic form, the majority of which is from the fuel. With solvent refined oils, when leaded fuels are used a grey deposit settles to the bottom of a sample of crankcase drainings and the upper portion assumes a light red colour from the dye in the fuel. Neither the colour given to the oil by the lead compounds or the dye nor the lead compounds themselves has been found to have any harmful effects on the lubrication value of the oil. Within a given range of viscosity, neither the type of lubricant nor the presence of lead compounds appears to be of importance in the rate of wear of Babbitt bearings, the same being true for Cd and Cu-Pb bearings at oil temperatures below 250 deg. Fah. Above 250 deg. Fah. the latter types may be attacked severely by some uninhibited solvent refined oils. Under such conditions the presence of lead compounds usually increases the rate of corrosion of Cd-Ni bearings, but drastically reduces the rate of corrosion of Cu-Pb bearings, sometimes by as much as 95 per cent. Extensive tests have not shown that lead compounds either accelerate or retard sludging. The effect of ethyl fluid in petrol on piston ring wear and oil consumption is insignificant at low loads and speeds, but materially reduces both under high-speed operation.

Air and Water

AIR SERVICE TO SOUTH AFRICA.—An extended Empire flying-boat service to South Africa has just begun. The once weekly flight to Kisumu has been extended to Durban and the flying-boat services have thus been restored to their pre-war frequency.

AMERICAN AERONAUTICAL EXPORTS.—Statistics of the United States Bureau of Commerce show that during 1939 aeronautical products to a total value of 117 million dollars were exported. Of these 42 million dollars worth were bought by France and 34 million dollars worth by Great Britain.

CIVIL AIRWAYS TRANSFER DATE.—The Air Ministry announces:—The Secretary of State for Air, Sir Kingsley Wood, has signed an Order fixing April 1st as the appointed day upon which the undertakings of Imperial Airways and British Airways are to be transferred to the British Overseas Airways Corporation.

THE HONOURABLE COMPANY OF MASTER MARINERS.—At the annual meeting of the Honourable Company of Master Mariners it was announced that Commodore Sir Bertram F. Hayes had been elected Master of the Company for the coming year. Commodore H. Stockwell was elected deputy-master, and Captain A. S. Mackay, senior warden.

SHIPPING CASUALTIES.—During the week ended Sunday, March 24th, eight neutral ships totalling 16,561 tons were sunk by enemy action. This is the first week since the war began that no losses of British or Allied vessels were recorded as a result of enemy action. Two German ships totalling 7136 tons were sunk off the Danish coast by British submarines.

THE RATE OF HIRE FOR SHIPS.—After a long discussion a meeting of the Chamber of Shipping to consider the rates which have been suggested by the Government for requisitioned deep sea cargo ships, was adjourned. It was considered necessary that before they could be voted on and accepted the terms offered by the Government should be understood and appreciated by the owners.

CLOSING OF PRINCES PIER, GREENOCK.—On April 1st, Princes Pier, Greenock, was closed to shipping and all descriptions of traffic. A considerable amount of money has been spent on repair work to the pier recently but it has been decided to close it until a complete examination has been made by the engineers, and on their report will depend whether or not it will be possible to re-open the pier without extensive reconstruction.

THE PANAMA CANAL IMPROVEMENT PROJECT.—A committee of the United States House of Representatives has refused to approve the expenditure of 227 million dollars on the immediate construction of the third set of locks at the Panama Canal. The budget had recommended an appropriation of 15 million dollars and authority to incur obligation to spend 99 million dollars to start work on the project. The committee considered the project was being pushed too rapidly and recommended an appropriation of 850,000 dollars to continue the design studies.

CANAL TRANSPORT.—If a scheme whereby more traffic could be conveyed by canal can be formulated, the Minister of Transport has announced that he will give some measure of financial assistance. In commenting upon this fact the *Journal of Commerce* points out that this country has 3461 miles of canals of which 2457 miles are owned by private companies, and the remainder are either owned or controlled by the railway companies. In spite of the fact that many of the canals have been allowed to fall into disuse, it is estimated that 12,500,000 tons of goods are conveyed each year on those still in use. It is estimated that ten times as much goods could be carried if the inland waterways system was developed.

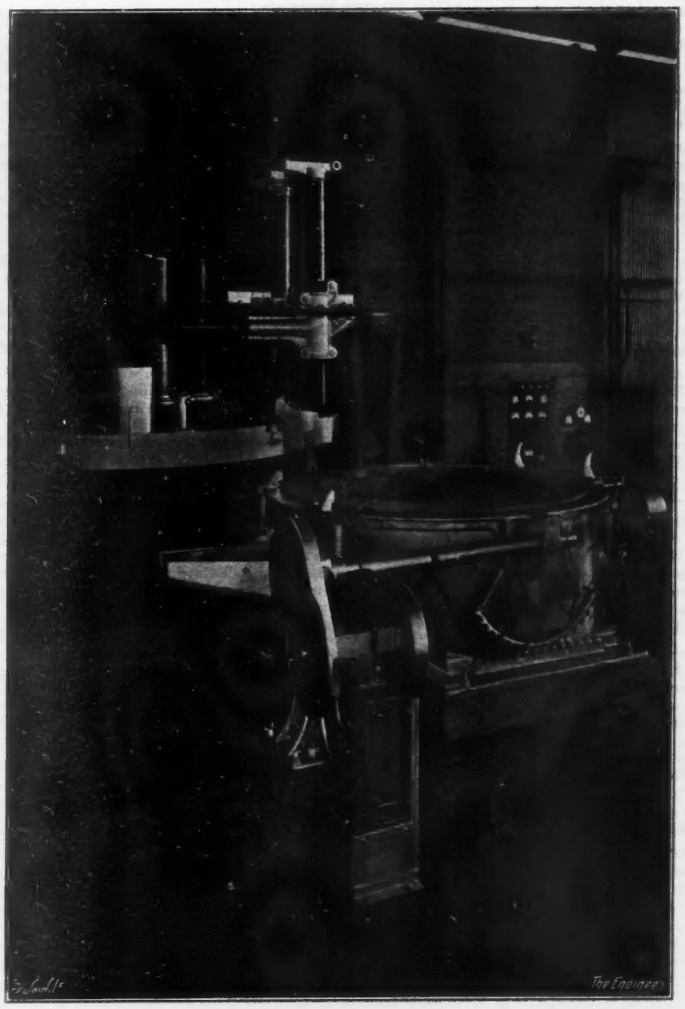
AN AIRCRAFT ASSEMBLY PLATFORM.—An interesting device used in aircraft assembly work which is made in the United States is described in a recent issue of *Flight*. It is known as the "rotary levelator" and is used for raising and lowering an aeroplane during the assembly processes so that workmen can do all their work while standing on the floor without any necessity to go up and down ladders and working platforms. The "levelator" is a platform 40ft. by 6ft. which can be easily raised or lowered relative to the factory floor by the two hydraulic pistons on which it is supported. Differential movement of the pistons allows the platform to be tilted with one end 4ft. above the other. It is stated that the company using these devices saves 800 man-hours of assembly labour on each aircraft.

STEAM PROPULSION OF CARGO SHIPS.—At a meeting of the Institution of Engineers and Shipbuilders in Scotland, Dr. J. B. O. Sneeden discussed the thermal performance of modern steam engines for the propulsion of cargo vessels. He said that since steam versus oil engine competition would always exist it was essential to the continuance of its position that the coal-burning steam machinery should receive the careful consideration of marine engine builders, and that its efficiency should be maintained and, if possible, improved. At the end of the paper Dr. Sneeden suggested that there was room for improvement in boiler efficiency; in pressure and temperature drops from boiler to engine stop valve; and in pressure drops from receivers to the cylinders of the reciprocating engine, as in most of the cases he had considered very severe drops were indicated.

H.M.S. "CALEDONIA" TO BE BROKEN UP.—The naval training ship H.M.S. "Caledonia" has been sold to Thomas W. Ward, Ltd., for breaking up. This vessel has had a very varied career. She was laid down at Hamburg by Germany in 1913 as the 56,599-ton liner "Bismarck" and was handed over to this country in 1921 under the reparations and became the White Star liner "Majestic." After serving on the Southampton–New York service she was sold for breaking up in 1936. It was then decided that she should instead be converted to a training ship, and was commissioned on April 23rd, 1937, as H.M.S. "Caledonia." She was booked for alterations just after the outbreak of the war but was badly damaged by a fire. A full description of the vessel as H.M.S. "Caledonia" was given in our issue of April 30th, 1937, and as the "Majestic" in our issue of May 13th, 1922.

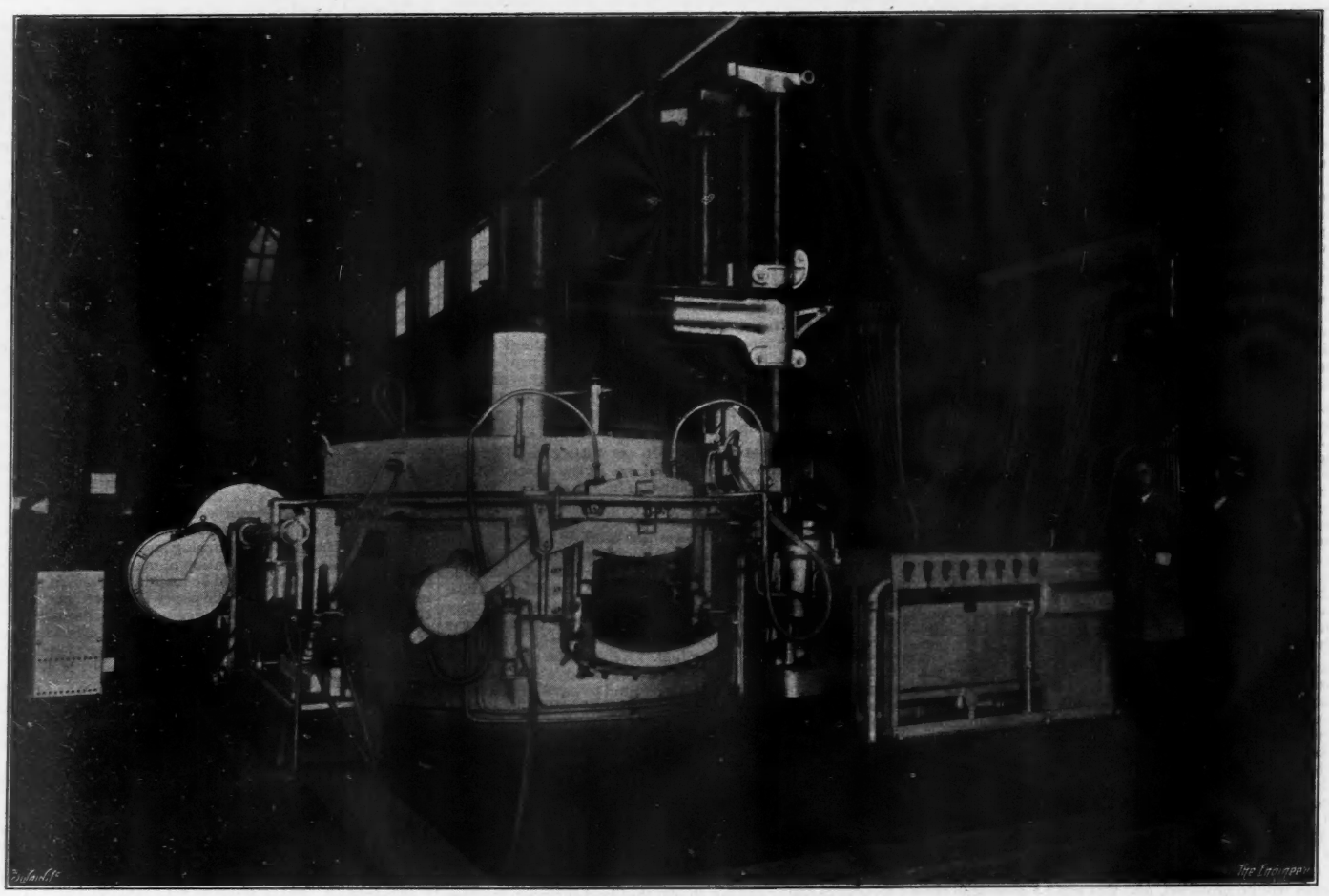
ARC MELTING FURNACE FOR JOHANNESBURG

(*For description see page* 333)



FURNACE WITH ROOF REMOVED

FURNACE TILTED FOR POURING



FURNACE IN WORKING POSITION

The Engineer

APRIL 5, 1940

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WAR MEASURES

PUBLISHING AND ADVERTISING

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GENERAL

The head office, 28, ESSEX STREET, STRAND, W.C.2, is open from Mondays to Fridays inclusive from 9-15 a.m. to 5-15 p.m., where classified advertisements may be handed in as usual and copies of the paper may be purchased. The office is not open on Saturdays.

PAPER SUPPLIES

With a view to the conservation of paper, readers are advised, in the interests of all concerned, to place a regular order for THE ENGINEER with their newsagent or direct with the Publisher.

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*** *All letters intended for insertion in* THE ENGINEER *or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.*

CHANGE OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have* **both the old and new addresses**, *as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

Postal Address: "The Engineer," 28, Essex Street, Strand, London, W.C.2.

Telegraphic Address: "Engineer Newspaper, Estrand, London." Telephone: CENtral 6565 (10 lines).

CHALLENGE IN THE AIR

ONE cannot but admire the courage with which the prevailing type of aero-engine was challenged in a recent discussion before the North-East Coast Institution of Engineers and Shipbuilders. Although Mr. W. S. Burn, who led the attack, described his own experience as well outside the aeronautical field, he thought his long acquaintanceship with other forms of internal combustion engine justified him in calling attention to undeveloped opportunities which the aero-engine designer might have seized but has not. As a general proposition, there is much to be said for the claim that advance is often made on unexpected lines by the bringing in of men accustomed to another technique. This was, for instance, most notably seen in the aeronautical field in recent years when the designing skill which produced the great airship R. 100 was transferred to heavier-than-air craft, and there speedily arose the now well-known geodetic method of airframe construction, with results seen at large in many of our present-day long range bombers, and incidentally in the world record for length of a single flight.

So here we have a challenge, not the first, to the existing form of aero-engine; one that has the merit of carrying the matter to its logical issue by the presentation of a definite alternative. Scrutiny of his proposals shows at once that although Mr. Burn may be right in claiming to be outside the circuit of aeronautical experts, he has none the less made himself familiar with the technical position of the aero-engine as it exists to-day. The claim is that the petrol engine should give way to an engine using safety fuel, a fuel of such low volatility as greatly to reduce the risk of crash fires, and capable of giving a horse-power-hour for a consumption as low as 0·32 pound—when used of course in the right kind of engine. The engine cycle proposed is the two-stroke compression ignition type, having opposed pistons as in the familiar Junkers engine. But in order to fit into the flat shape of the aeroplane wing, it is proposed that the engine should itself be flat, having three rather large cylinders on each side of the crankshaft, and giving in all 2100 H.P. The choice between air-cooling and water-cooling is solved by the unexpected method of not using either, placing instead this considerable duty on the oil circulation. The engine is to be so disposed in the rear half of the wing as to be easy of access for adjustment during flight, and to be conveniently disposed to take a pusher-air-screw.

Here, in short, is the latest challenge by the compression ignition partisans to the existing type of aero-engine. To meet with any success it has to be assumed that the fuel injection apparatus is at least as free from fear of breakdown, or interrupted service, as is the customary combination of carburettor and magneto. The importance of this point can hardly be too highly stressed since the entire dependence of the life of the whole structure rests on the ability of the engine to give continuous duty. The result of engine failure may be absolute disaster. So much attention in fact does the engine demand that it is rather alarming to picture this large flat engine so tucked away that it cannot be readily replaced as a whole. The ability to change the engine as a complete unit is a convenience which has much in its favour, and is possessed by many present-day types. Mr. Burn naturally, however, views his engine with parental pride, and makes claims for it which are decidedly full-blooded; as, for example, its requiring less supercharging at altitude than the petrol engine, though in fact what is lacking at such altitudes is air, not fuel, and the atmosphere can be counted upon to be impartial between rival types of oxygen-consuming apparatus. But boldness goes a long way when it is suggested that in the case of such an engine being fitted to flying-boats it might be feasible, in order to overcome pusher-air-screw difficulties, to use rotatable stub floats in place of the customary transverse hull step. To anyone with knowledge of the intricacies of flying-boat hull design, with the peculiarities of stub floats, and with the sensitivity of the shape of the underwater portion of the hull, it will be a shock to find such complexities treated lightly as a small step towards the production of an improved engine. Nevertheless we welcome this challenge and we hope that those in high authority will consider it with the care it deserves. Germany has her own reasons for wanting to use the less volatile fuels, but her assiduity in working at compression ignition designs must not be allowed to leave us behind, especially in their application to the long range aircraft needed for ocean going patrols.

A Problem in the Philosophy of Mathematics

HOWEVER exact we may succeed in making our practice it cannot be contended that engineering is to be numbered among the "exact sciences." No one in any branch of our profession needs to be told that engineering is a perpetual struggle for compromise, and that all the theories on which we base our calculations and design rest knowingly on assumptions, simplifications, and approximations which may reproduce practical conditions with sufficient similitude for our purpose but which just as frequently quite clearly fail to do so to an extent sometimes gross and sometimes quite indeterminate. So long as engineers are compelled for the sake of ensuring safety to use in their designs "factors of safety" of six or seven so long will they be unable to claim that theirs is an exact science. All that is not the fault of the engineer. Largely it may be laid at the door of him who makes our theories for us or who gives us the tools by which we construct them—the mathematician. Of all branches of study mathematics is the only one which, with any show of reason, may be claimed to be an exact science. In actual fact the claim may be seriously challenged. Anyone who proceeds in his mathematical studies much beyond the didactic elementary stages with their seeming eternal verity and exactitude will soon find, perhaps to his amazed disillusionment, that in the higher sections mathematics is regrettably compelled to resort to subterfuge in order to avoid defeat in certain directions. It makes assumptions and adopts approximations just as freely as do we in the practice of engineering. It is compelled to do so because of its strictly limited ability to manipulate the symbols in which it clothes its processes and conclusions. Unfortunately before it passes on its findings to us, whether as definite pronouncements or as tools for us engineers to use, it does not always take scrupulous care to see that the limitations of those findings are fully impressed upon us.

No such thing as a "simple pendulum" exists in practice, but on the assumption that we can get within reasonable distance of realising it, the mathematicians have given us a simple formula for calculating its periodic time as a function of its length, namely, $T=2\pi\sqrt{l/g}$. This is not an exact formula. The period *does* depend on the amplitude of the swing even in the case of an idealised simple pendulum. The true period is $T \times F$ where F is a factor which no mathematician has yet succeeded in expressing completely with the aid of a finite number of symbols. All that can be done is to express F as an unending series of terms involving powers of sine α where α is the angle of swing of the pendulum. For numerical values of the series corresponding to any angle α we must consult tables of elliptical integrals. Let us suppose that we go a step further and arrange the pendulum to oscillate with its bob immersed in a viscous fluid. We turn to the mathematician to tell us how to calculate its period in these circumstances. He will begin by writing down a differential equation: $\ddot{x}+2b\dot{x}+a^2x=0$ which he will then proceed to solve. The solution arrived at is decisive in its exactitude, but there is a serious flaw in the premises from which it was drawn. The second term of the differential equation implies that the viscous resistance experienced by the bob is proportional to the first power of the velocity with which at any instant it is moving through the fluid. Experiment shows that, at least when the velocity is other than minute, the

resistance is proportional much more nearly to the square of the velocity than to its first power. We therefore re-write the equation as: $\ddot{x}+2b\ (\dot{x})^2+a^2x=0$ and pass it back to the mathematician for solution. He will at once return it to us with an expression of regret that it is beyond his ability to solve it. Unless it is assumed that the resistance is proportional to the first power of the velocity mathematicians are unable to tackle the problem of determining the period of the pendulum. In returning the problem to us the mathematician would doubtlessly call our attention to two facts of serious import in our statement of it. He would point out in the first place that if we object to his assuming that the resistance at all velocities, high or low, is proportional to the first power of the velocity he, with equal justice, may object to our assuming that it is uniformly proportional to the square of the velocity. Secondly, he would assuredly tell us that, quite apart from this factor, the problem as we have presented it to him is not really the problem we are trying to solve and that our equation implies the existence of conditions which do not occur in nature. There can be no challenging of this assertion. The second, or "damping" term in our equation makes the resistance proportional to the square of the velocity. But, since the square of any quantity is always positive, whether the quantity is positive or negative, the implication is that the damping force resists the motion of the bob when it is moving in one direction and *assists* it when it is moving in the other. Our equation, in short, implies the existence of something which may be described as "negative damping." We are, however, not yet defeated. Rewriting the equation in the form $\ddot{x}+(R+S\dot{x}^2)\dot{x}+a^2x=0$ we return it once more to the mathematician with a note to the effect that both his objections have now been removed. The damping term, $R\dot{x}+S\dot{x}^3$, will be positive or negative according as the velocity $\dot{x}$ is positive or negative, that is to say the damping will always oppose the motion of the bob in whichever direction it is moving. Again, if the coefficients R and S are suitably chosen the damping force will be proportional substantially to the first power of the velocity at low speeds, to the cube of the velocity at high speeds and to the square of the velocity at intermediate speeds. We might add, although the mathematician would be quick to see it for himself, that the equation in this second revised form is almost identical with the equation $\ddot{x}+K\ \tan(n\dot{x})+a^2x=0$, for, using the mathematical device of expanding $\tan(n\dot{x})$ as a series, it will at once be seen that the first two terms of that expansion reproduce the form $R\dot{x}+S\dot{x}^3$, the subsequent higher powered terms being increasingly negligible. We could also point out that if the mathematician does not like the equation in this form, other forms such as one involving the writing of the damping term as $K\ \sin^{-1}(n\dot{x})$ can be equally well used.

Can the mathematician solve the equation in the form in which we have now given it? We have never seen a solution of it, but there would seem to be some evidence that it is solvable. It seems to us, however, that a greater issue is at stake in this matter than the mere solution of a particular equation. Here we have a problem which can be solved if we allow the mathematician to make an assumption which from experimental evidence we know to be unjustified. When we make a first effort to restate the problem in harmony more or less with experimental fact we encounter an equation which, it is known, is beyond the powers of mathematics to solve. When finally we again restate the problem in terms which can be made to reproduce experimental facts to within the limits of observational errors we get an equation which, it is not unreasonable to believe, can be solved by established mathematical processes. This question then remains to be answered: Is mathematics an essentially incomplete, imperfect science which is apt to break down when we seek to hold it too rigourously to natural fact? The alternative conclusion is that the fault lies in our limited power of observing natural fact, that mathematics is an expression of eternal truth and that when it seems to stumble, halt, or fail over a problem set before it, it is because the conditions of the problem have not been correctly stated. The implications of this alternative conclusion are tremendous. It would mean in the case of our example that because the equation in one or other of the finally revised forms can be solved the law of viscous resistance must be in accordance with the terms of the equation. In a wider field it would mean that the seeming failure of classical mathematics to deal adequately with recent developments in the philosophy of physics, such as the quantum theory, is not a call to the formulation of a new system of mathematics, but an inescapable sign that the philosophy is wrong.

Literature

The History of the Institution of Electrical Engineers (1871–1931). By Rollo Appleyard. London: The Institution of Electrical Engineers.

This volume, as interesting as it is handsome, was prepared at the official request of the Institution and relates chiefly to the sixty years from 1871 when the Institution—then known as the Society of Telegraph Engineers—was founded, to 1931, the centenary of Faraday's discovery of "the production of electricity from magnetism." The narrative is not, however, rigidly confined to the period between these dates. It extends as far back into the history of electricity as is necessary to make the reader familiar with the state of the science at the date of the Institution's foundation and makes occasional reference to advances made since 1931. It also turns back into ancient history to give us a connected account of the Savoy, that celebrated parcel of land between the Strand and the Thames on which the Institution's headquarters now stands.

The Society of Telegraph Engineers was founded on May 17th, 1871, by eight men—three civilians, one naval officer, and four army officers—who met for the purpose at No. 2, Westminster Chambers, Victoria Street, London. Immediate support was received from a number of men whose names are still famous in the annals of British science. A fortnight later the Society was duly constituted with Charles William Siemens as its president. The Institution of Civil Engineers gave the new Society its blessing and allowed it to use its Great George Street headquarters for its meetings from 1872 until 1896. By the end of 1873, the Society had enrolled about 450 members, its chief supporters being representative of the British Postal Telegraphs, the fighting services, the railway telegraph departments, and current natural science. In the first few years of its existence the Society was not free from financial troubles arising, principally, from slackness on the part of the members in paying their subscriptions. In an effort to remedy the situation the secretary was given a commission of 5 per cent. on all subscriptions more than a year in arrears which he could manage to collect. This scheme failed, deservedly it may be considered, but by 1878, following a threat to remove the names of delinquents from the membership roll and the establishment of a committee to watch over the financial position, the situation had considerably improved and although it remained difficult for some time longer it gradually ceased to give anxiety.

As early as 1873 the question of admitting ladies to membership of the Society arose. The council approached the Institution of Civil Engineers as to the propriety of admitting ladies to the lecture theatre at the Great George Street headquarters and, receiving an unfavourable reply, postponed further consideration of the proposal. Five years later the plea for the admission of women members was renewed. The council rejected it, but some of the ordinary members disagreed with the decision and urged that the Society should open its doors to any female telegraph operator who might desire to join it. In 1888 the ladies succeeded in so far that while they were still denied membership they were not debarred from attending the meetings.

Before the Society was ten years old, the advent of the telephone and the increasing development of electricity as a source of illumination rendered the original title too narrow for the field which the Society's interests began to cover. Accordingly in 1881 it changed its name to the Society of Telegraph Engineers and of Electricians, subsequently modified to the Society of Telegraph-Engineers and Electricians. By 1884 the character of the meetings of the Society showed that the supply and sale of electricity, and the design of dynamos, cables, safety devices and meters were beginning to thrust the subject of telegraphy into the background. It was round about the same date that Parliamentary enactments, well intentioned but badly conceived, threatened to restrict the growth in the use of electricity for domestic lighting purposes to such an extent as to discourage capitalists from investing their money in promoting schemes to that end. The Society took active steps to have the situation remedied. It was fortunate in having Lord Bury as one of its members. In 1886 Lord Bury laid a petition from the Society before Parliament protesting against the offending clauses of the Electric Lighting Act of 1882. A select committee of the House of Lords was appointed and in 1888 a number of reforms took effect.

The financial situation of the Society had improved to such an extent that by 1886 the honorary treasurer was able to report that the Society's bank balance was much larger than was likely to be required to meet current expenses. It was therefore decided to establish a general investment fund. The growing financial strength also, no doubt, was the principal reason for another action on the part of the Society about this time. It instituted a scrutiny of its members and struck off the register all those whose subscriptions were more than two years in arrears. This purge lead to the "resignation" of four foreign members, eight members, twenty-six associates, and twenty-six students. Among the victims of it were Professor F. Guthrie, Oliver Heaviside, Jablochkoff, and Arnold White. Heaviside's elimination from the list of members was particularly unfortunate from the point of view of the Society. He had been elected an associate in 1874, but by 1881 his financial position was such that he was unable to pay the four guineas for his annual subscription. His name was placed on the "black list" and in November, 1885, it was finally struck off the register. He accepted the verdict calmly and rejected in advance that any special favour that might have been shown to him. In 1908 the Society—the Institution by that date—offered him recompense and did itself honour by electing him an honorary member. Heaviside lived to enjoy the honour until his death in February, 1925.

Towards the end of 1887 a feeling began to grow that the Society did not adequately represent the electrical engineers of the country, and that it was divorcing itself from the promotion of practical objects. In some quarters the suggestion was heard that a new and rival society should be established, the membership of which should be confined to electricians and engineers only and of which the prime object would be to shape the practice of electrical engineering into "something like an art, having some definite rules and principles." To meet this threat, W. H. Preece, on November 17th, 1887, proposed to the council that the title of the Society should be changed to "The Institution of Electrical Engineers." Backed by R. E. Crompton and Alexander Siemens, a motion to that effect was carried unanimously by the council. The members were circularised on the subject and by October, 1888, assent to the proposed change had been expressed by 837, with 9 dissenting, and 11 suggesting slight modifications in the title. The change was duly confirmed at a special general meeting of the Society on January 10th, 1889, on which date also Sir William Thomson delivered his address as the first president of the "Institution." He had been president of the Society fourteen years previously and during the interval its membership had grown from about 570 to about 1500. Thomson's second presidency marked the end of the transition period which lay between the days of the early pioneers of electrical science and the dawn of the electrical age in which we now live.

For a time the telegraphists and telephonists sought to maintain their old position in the affairs of the Institution. These were the days, however, of Crookes, Tesla, Fleming, Kapp, John Hopkinson,

Rayleigh, and Heaviside. Electrical science and practice was broadening its scope at an amazingly rapid rate and soon the generation and distribution of electrical energy and its application in many fields hardly conceivable a few years previously began to dominate the Institution's interests. A small but significant item revealed clearly the change which had occurred. At the annual dinner of the Institution in 1894 all the food was cooked by electricity. Behind that simple incident lay the fact that by that time the Metropolitan Electric Lighting Company was in being and ready and able to supply the necessary current, and that firms such as Crompton and Co., the General Electric Company, and Siemens Brothers and Co. were in existence and were in a position to supply the necessary apparatus.

Electric traction for tramways and railways was being actively studied. In the United States in 1894 there were 600 electric tramways operating about 9000 miles of track and possessing 20,000 cars. In this country we were proceeding more leisurely and cautiously in that direction, but the number of electricity supply works in service was rapidly increasing and where fuel was cheap electrochemical and electro-metallurgical works were being established. The new horizons towards which the science and practice of electricity was spreading had their effect on the Institution. At the beginning of 1895 the influx of new members had raised the membership roll to 2448.

As early as 1886 the council of the Institution had favourably considered a proposal for the establishment of a National Standardising Laboratory. It was held that the work of such a laboratory should, in the first instance at least, be limited to the checking of resistance coils, standard cells, voltmeters, and ammeters. The capital outlay was estimated at from £250 to £300. A room at King's College, London, was placed at the disposal of the council in which to house the proposed laboratory. The co-operation of the Royal Society and of certain electrical manufacturers was sought, and in 1889 definite proposals for the establishment of the laboratory were formulated. The estimated cost had now risen to £3,500. At the same time the opinion began to grow that the proposed laboratory should be a Government establishment. Throughout the 'nineties the scheme hung fire. It was not until April, 1899, that the Institution's advocacy of it was rewarded by the receipt of an invitation to appoint two of its members to serve on the General Board of the National Physical Laboratory, then about to come into being.

The Institution, growing with the growth in the applications of electrical science, had, in 1890, became conscious of the disadvantages under which it suffered by virtue of its lack of a permanent home of its own. The hospitality of the Institution of Civil Engineers was a privilege which it could not expect to enjoy for ever. The first step towards acquiring a home for the Institution was taken in April, 1890, by Sir David Salomans, who suggested the formation of a building fund by setting aside 75 per cent. of the surplus revenue of each year. In 1894, the building fund was launched by transferring £3000 to it from the general investment fund. From many different sources contributions to the fund began slowly to come in. By the end of 1902 it was approaching £11,000 and the first steps were taken towards acquiring a building or a building site. Negotiations were began for the purchase of the Catholic Archbishop's Palace, Victoria Street, London, but just as they were about to be completed the vendors withdrew their offer. Shortly afterwards a site in Tothill Street, Westminster, attracted attention and it was decided to purchase it at a price of £16,500. The purchase was completed in March, 1904, but it soon became evident that the site was too small for the erection of a building commensurate with the Institution's growing stature. It was therefore decided not to proceed with the erection of a building on the site and to continue the search for suitable accommodation elsewhere. In June, 1908, it was found in the Royal Medical Colleges, Victoria Embankment, Savoy Place. The lease of this building, with 76 years unexpired, was purchased for £50,000. Structural alterations of the building were required in order to make it suitable for the work of the Institution, but by November, 1910, the work was sufficiently advanced to enable the Institution to hold the first meeting in its own home. The Tothill Street property was shortly afterwards sold at a profitable figure. The accommodation provided by the new building was more than ample for the needs of the Institution. Accordingly portions of it were let to various tenants. In May, 1923, the British Broadcasting Company very appropriately found shelter in this way under the Institution's roof. When it—now the "Corporation"—departed in 1932 to its new headquarters in Portland Place a period, we may think, came to an end, a period which began simultaneously with the foundation of the Institution when men were still a little amazed at the latest scientific achievement, the ability to transmit messages by land line and submarine cable instantly to the most distant parts of the world. The period ended with a new amazing scientific achievement, the ability to transmit the message of a single voice simultaneously to millions of people. We can well imagine a smile stealing across the sleep of those early telegraph and telephone engineers who so frequently and strenuously protested against the increasing exclusion of their particular studies from the interests of the Society which they had founded.

Against this background of the domestic history of the Institution Mr. Appleyard has built a work which is really a chronicle of the development of electrical science from remote times until the present day. The story as he tells it is a most readable one. It is not an impersonal narrative of the discovery of electrical facts, but in large part a personal account of the men who made them, how they made them, and the conditions of the times in which they were made. Many an anecdote, many an instructive or amusing extract from the Institution's "proceedings" or its council's minutes are scattered throughout the pages. There are some notable accounts of the great days of the past, by aid of which we of this generation are enabled to recapture something of the excitement which attended certain of the early meetings of the Institution when the latest discoveries were laid before it by their authors. Merely to name some of those meetings is sufficient to indicate the greatness of the occasions for which they stood. In 1873 Willoughby Smith announced to the Society his discovery of the variation of the electrical resistance of selenium when exposed to the action of light. In October, 1877, Graham Bell described his researches on the telephone. In May of the following year David Hughes laid before the Society full particulars relating to his discovery of the microphone. In November, 1880, J. W. Swan read a paper on the subdivision of the electric light and illustrated his remarks by means of his newly invented carbon filament lamps. In his presidential address in January, 1891, William Crookes revealed to the members the effects of the passage of electricity through rarefied gases. A year or so later, in February, 1892, Nikola Tesla delivered a lecture on the induction coil and high frequency alternating currents. On March 2nd, 1899, Marconi addressed the Institution on wireless telegraphy. Many members on that great occasion had been unable to obtain admission to the overcrowded meeting room and were not satisfied until Marconi repeated the lecture a fortnight later. Many another meeting of the Society or Institution might be mentioned at which the proceedings, if at the time they seemed to be of an ordinary character, can now, in the light of later knowledge, be accepted as marking occasions from which the future developments of the science of electricity or the practice of electrical engineering were to arise. A mere recital of a few of the names of those who took part in the early discussions at the Institution meetings will be sufficient to indicate the truth of this assertion. Latimer Clark, Carey Foster, Fleeming Jenkin, Sir William Thomson, John Tyndall, H. R. Kempe, Cromwell Varley, Charles Wheatstone, G. B. Airey, Clerk Maxwell, and David Hughes were among the first to join the society, and for many years we find them contributing regularly to the discussions. Soon they were joined by William Crookes, Fletcher Moulton, W. E. Ayrton, John Perry, W. H. Preece, the brothers Siemens, Heaviside, Sir Charles Bright, R. E. Crompton, John Hopkinson, J. A. Fleming, S. P. Thompson, Gisbert Kapp, Oliver Lodge, and many another of those whose names are still remembered and honoured in the annals of electrical science.

Mr. Appleyard has been fortunate in his subject and has done full justice to it. His book makes pleasant and instructive reading. It is perhaps not wholly his fault if after we have laid it down we are left with the feeling that the Institution will never again experience times such as befell it in its early days and never again gather within its membership roll, however swollen it may now have become, the names of such a brilliant galaxy of men as those who supported it in its youth. In other words, we are left with the impression that the best days of the Institution are past. Were the Institutions of Civil Engineers and Mechanical Engineers to compile corresponding histories of their activities it is certain that after perusing them the reader would be left with the same impression. It must be so, because they grew up during a period when civil and mechanical engineering were being practiced by the men whom we now regard as the pioneers of those professions and when the general foundations of their arts were being established. Those days witnessed historic discoveries and developments and in retrospect seem much fuller of incident and excitement than our own times. Further, there is a glamour about the personalities of a former age which we do not feel about those of our own times. These factors are particularly marked in the history of the Institution of Electrical Engineers, which was founded at a time when electrical science and practice was just about to burst the bonds which had confined it to the laboratory and to electric telegraphy. The progress made during its adolescence was rapid, far more rapid than that of the corresponding eras of the two sister Institutions, and the men who shaped that progress were for the most part peculiarly picturesque characters. If, then, we contrast the present activities of the Institution with those of its youth, as inevitably we must do after reading Mr. Appleyard's book, and if we feel that those of to-day are dull and lacking in thrilling episode let us remember that we cannot see our own age and our own contemporaries clearly. It will be for a future generation to say whether we of this one have lived up to the standard set us by our forebears. Possibly they will find our proceedings as full of excitement and interest as we do those of the founders of the Institution. Possibly too—a strange thought—they will judge us equally picturesque in our appearance, characters, and habits.

SHORT NOTICES

Civil Defence. Second Edition. By C. W. Glover, M. Inst. C.E. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 36s. net.—Few branches of industry have received so much attention during the past few months as that with which this book deals, and its widening scope may be appreciated from the fact that this, the second edition, is more than double the size of the first which was published less than eighteen months ago. It covers very thoroughly the types of aerial attack which may be expected—high explosive, incendiary, and gas bombs—the results which may be expected from their use and the best means at present known for protection against them. Full details of the lay-out of a wide range of trenches and shelters are given, and designs are illustrated for the means of protecting a few people up to whole communities. Architects and constructors will find much useful information on the methods of strengthening existing buildings and the provision of protected areas in such structures. The camouflaging of industrial and other buildings is dealt with in some detail, and a number of ways of effectually obscuring large window areas at night are clearly explained. The contents of each section are supplemented by numerous illustrations and drawings. Much useful information is included in chapters on the organisation of personnel for A.R.P. measures and the costs involved in the provision of protection. This is the most comprehensive manual on the subject we have yet seen, and there is no doubt that it will be of considerable use to all concerned with civil defence.

The Gas Producer Operator's Handbook. By D. R. G. Crawford. London: Crosby, Lockwood and Son, Ltd., Stationers' Hall Court, E.C.4. Price 4s. 6d. net.—The object of this little handbook is to explain to producer gas operators the methods by which the best results can be obtained. In simple language it describes the theory of producer gas manufacture, producer operation, gas analysis, and calculations. The latter part of the book describes, with the aid of drawings and illustrations, some types of producers and instruments.

BOOKS RECEIVED

Directory of Shipowners, Shipbuilders, and Marine Engineers, 1940. London: Directory Publishing Company, Ltd., 33, Tothill Street, S.W.1. Price 20s. net.

Telephony. By T. E. Herbert, M.I.E.E., and W. S. Proctor, A.M.I.E.E. Supplement to Volume II. London: Sir Isaac Pitman and Sons, Ltd. 1940. Price 3s. 6d.

Modern Factory Lighting: Including Special Wartime Requirements. Issued jointly by the British Electrical Development Association and the E.L.M.A. Lighting Services Bureau, 2, Savoy Hill, W.C.2. Price 8s. 6d. net.

Export of I.C. Engines

As announced in our "Journal" last week, the Internal Combustion Engine Manufacturers' Association has set up a War Export Group to handle problems associated with the promotion of the export trade of internal combustion engines and with the allocation of material for the construction of such engines. The group which is initialled I.C.E.W.E.G.—Internal Combustion Engine War Export Group—has just issued a Red Book from which the following particulars about its constitution and activities are abstracted.

The Internal Combustion Engine Manufacturers' Association came into existence on November 1st, 1939, for the purpose of furthering the welfare and improving the organisation of the internal combustion engine industry so far as included within the scope of the association. The association covers principally, the manufacture and sale of internal combustion engines within the following ranges :—

(*a*) Stationary land engines of all types and sizes,
(*b*) Marine engines (not exceeding 1500 B.H.P.) with the exception of marine engines made by automotive or aeroplane makers such as Morris Motors, Ltd., or the Austin Motor Company, Ltd.,
(*c*) Diesel locomotives.

The members of the association include all the principal manufacturers of internal combustion engines within the above ranges. Apart from sales within the United Kingdom and engines manufactured for or sold to Government Departments, members of the association are responsible, in normal times, for over 90 per cent. of the export overseas of internal combustion engines from the United Kingdom. In the case of many members of the association, before the present war, substantially more than 50 per cent. of their output of internal combustion engines went into export markets. The offices of the association are at 32, Victoria Street, London, S.W.1. The secretary is Mr. Herbert Cowper, F.C.I.S. The official telephone number of the association is ABBey (London), 2181, and its registered inland telegraphic address "Intcomenas, Sowest, London."

The association has appointed Sir Lynden Macassey, K.B.E., K.C., D.Sc., to be its independent chairman. In addition to exercising a directive responsibility over the association, he maintains a private secretariat at 32, Victoria Street, S.W.1, apart from the association's general offices, for the purpose of confidential consultations with members of the association. His own private telephone number at that address is ABBey 6522, and his personal registered inland telegraphic address "Yessacam, Sowest, London."

The export trade in internal combustion engines as such is particularly valuable. The very considerable figure to which it amounts indicates only a part of the value it represents. Orders from overseas markets ordinarily include not merely internal combustion engines but various kinds of machinery driven by the engines. These orders for driven machinery, it is fair to assume, would not be placed in the United Kingdom if the internal combustion engines to drive the machinery were not being ordered in it.

Action taken by Association on White Paper.—Immediately after the publication, on March 6th, of the White Paper, the association took action to give effect to what had been ascertained was the desire of the President of the Board of Trade as well as to the recommendations in the White Paper of the Export Council. On March 13th, the association decided by unanimous resolutions at a general meeting as follows :—

(1) To constitute the association a self-governing War Export Group under the name of the Internal Combustion Engine War Export Group to exercise the functions of such a group as outlined in the White Paper so far as relates to internal combustion engines comprised within the ranges covered by the association and such other ranges (not included within the scope of any other War Export Group) which it is desired by the Export Council should be comprised, with the independent chairman of the association (Sir Lynden Macassey) as chairman, and the secretary of the association (Mr. H. Cowper) as secretary.

(2) For the War Export Group so constituted to co-operate to the fullest possible extent with the Export Council in promoting export trade in internal combustion engines within the above ranges.

(3) In order to meet the views of the Export Council that the War Export Group so constituted should be as completely comprehensive as possible of the manufacturers of internal combustion engines within the above ranges, to extend membership of, with an invitation to join, the group to all manufacturers of such engines without their coming under any obligation to join the association if they do not care to do so, provided they agree to pay in common with the members of the association their proportion of the expenses of the group.

(4) For the War Export Group to regulate its activities and administer its affairs by resolutions passed by general meetings of the members of the group.

(5) For the purpose of representing and acting on behalf of the War Export Group and for consultation with the Export Council, to constitute an executive committee consisting of :—

Sir Lynden Macassey, chairman; Mr. H. S. Aspinall, general export manager, English Electric Company, Ltd.; Mr. D. M. Denholm, director of Norris, Henty and Gardners, Ltd.; Mr. Percy Lister, chairman of R. A. Lister and Co., Ltd.; Mr. H. B. Riggall, director of Ruston and Hornsby, Ltd.; Mr. H. B. V. Teague, general sales manager, Crossley Bros., Ltd., and director of Crossley-Premier Engines, Ltd., with power to co-opt one other member of the group who was not a member of the association.

It was decided at the same meeting that the resolutions to the above effect should come into operation as soon as they were approved of by the Export Council.

The above resolutions and others embodying machinery required to give effect to them were submitted on March 13th to the Export Council and were approved.

Materials for Export Trade.—Members of the association for some time had been experiencing difficulty in securing a continuous and adequate supply of materials for the production of internal combustion engines for the export trade. The association accordingly appointed an Export Trade Materials Committee to investigate and make recommendations as to how the difficulty could best be met. The committee consisted of :—

Sir Lynden Macassey, independent chairman of the association; Mr. H. S. Aspinall, general export manager, English Electric Company, Ltd.; Mr. Percy Lister, chairman of R. A. Lister and Co., Ltd.; Mr. H. B. Riggall, director of Ruston and Hornsby, Ltd.; Mr. H. B. V. Teague, general sales manager, Crossley Bros., Ltd., and director of Crossley-Premier Engines, Ltd.

After considerable discussions between the committee and the Board of Trade, and also between Sir Lynden Macassey and the various controllers, the committee formulated a scheme for ensuring a supply of materials for the export trade in internal combustion engines.

In discussions with the controllers concerning the scheme Sir Lynden Macassey undertook that a technical committee would be formed to consider whether and, if so, in what ways and to what extent the use of certain controlled materials might be economised or substitutes for them adopted in the production of internal combustion engines. Accordingly, the War Export Group, on its formation on March 13th, constituted a committee consisting of one representative to be nominated by each of the following firms, viz.:—

W. H. Allen, Sons and Co., Ltd.; Davey, Paxman and Co. (Colchester), Ltd.; Mirrlees, Bickerton and Day, Ltd.; Petters, Ltd.; and one other firm to be selected by the executive committee, to investigate and make a report, and if possible recommendations upon the matter to the controllers concerned and to the members of the War Export Group.

Returns and Estimates by Members.—There will be immediately sent to every member of the War Export Group by Sir Lynden Macassey (unless he is getting his materials under some other scheme), forms on which each member will be required to set out the amounts of each of the controlled materials to which the forms relate that were actually used by him during the year 1938 for his export trade in internal combustion engines, including spares. The form is intended to give an accurate and verifiable statement as nearly as can be ascertained of what in fact were the quantities measured in weight of the controlled materials that were used. The totals on the forms must be certified as correct by the managing director or a chief executive of the firm in question.

There will also be sent, at the same time, to such members of the War Export Group, other forms on which each member must set out, under the certificate of his managing director or some chief executive, his detailed estimate of the amounts of each of the classes of the controlled material to which the form applies, required by him for his export trade in internal combustion engines, including spares, for the 12 months, 1940–41, commencing from when the scheme comes, into operation.

As the accuracy of the returns and reasonableness of the estimates are required by the controllers to be subjected to close scrutiny by Sir Lynden Macassey, or, if required by him or any controller, to detailed investigation by the firm of chartered accountants appointed by the War Export Group for the purpose, viz., Messrs. Deloitte, Plender, Griffiths and Co., the estimates should be prepared on a careful basis with reasoned regard to practicable potentialities.

When the 1938 returns and the 1940–41 estimates have been completed and certified they must be forwarded in special confidential envelopes, which will be supplied with the forms, to Sir Lynden Macassey at his private office at 32, Victoria Street, London, S.W.1.

When the returns and estimates referred to above have been scrutinised, collated, and aggregated by Sir Lynden Macassey, he will then submit to the various controllers and also to the Board of Trade the totals of the controlled materials which, in his opinion, are required by the whole of the members of the War Export Group for their export trade in internal combustion engines, including spares, during the 12 months, 1940–41, commencing from when the scheme comes into operation.

If any question arises with any of the controllers regarding the totals of the 1940–41 requirements, Sir Lynden Macassey, if he is unable to adjust the matter, will report it to Sir Clive Baillieu for such action to be taken by the Export Council as they think is justified.

Secrecy in regard to Returns and Estimates.—It is a fundamental condition of the scheme that all the returns and estimates made to Sir Lynden Macassey by any member of the War Export Group in regard to his export trade in internal combustion engines, shall be kept secret and not divulged by him or his staff to anyone except to a controller concerned, or to the Export Council, or Messrs. Deloitte, Plender, Griffiths and Co.

Allocation and Distribution of Allocated Material.—On submission to the controllers concerned of the total materials requirements for the 1940–41, 12 months, it will then be the duty of Sir Lynden Macassey to ask the controllers to allocate for the first six months of the 1940–41, 12 months, such proportion of the totals as he thinks are required by the members of the War Export Group for their export trade during those six months.

The scheme contemplates that the respective controllers will, except when prevented by some special emergency, allocate to the War Export Group the totals for the six months requisitioned by Sir Lynden Macassey.

On allocation by the controllers concerned of the totals of the materials requisitioned as described above for the ensuing period of six months, the scheme provides that the totals shall be distributed among the members of the War Export Group by Sir Lynden Macassey, who in doing so shall have regard to the estimates submitted by the members of their 1940–41, 12 months, requirements, but shall be entitled also to have regard to any other circumstance which he thinks relevant and to make such inquiries and investigations as he thinks proper, and his decisions in regard to distribution shall be final and without appeal except that he may review and vary them in any case in which he thinks there is sufficient reason to justify his doing so.

Sir Lynden Macassey will then communicate to each controller concerned the exact amounts of the different classes of the material controlled by him which have been distributed to each member. That will represent the total amount of the material in question which the member will be entitled to obtain for the needs of his export trade in internal combustion engines during the six months in question. The provisions as to secrecy will apply to the amounts so distributed.

It is an unconditional requirement of the scheme that all materials distributed and supplied to a member of the War Export Group for the purposes of his export trade in internal combustion engines, including spares, shall be used by him exclusively for that purpose and none other. In case of any question arising as to whether, in any particular case, the condition has or has not been complied with, Sir Lynden Macassey will be entitled to make such investigation as he thinks fit.

It is intended to put the scheme into immediate operation.

BOOKS OF REFERENCE

The Blue Book, 1940. *The Electrical Trades Directory and Handbook*. London: Benn Brothers, Ltd., 154, Fleet Street, E.C.4. Price 25s. net. The arrangement of the new edition of this wellknown reference book is similar to that of earlier editions. It is in four main parts—commercial and technical data, including lists of officers of trade and professional organisations; an alphabetical list covering firms, persons, and societies in the electrical and engineering industries; a geographical section; and a classified section. Lists of trade names and telegraphic addresses are also included. For many years the book has been widely used as a source of information in the electrical and allied industries and users will find the new edition as complete and accurate as the earlier issues.

Steel Construction. Handbook No. 22. London: R. A. Skelton and Co., Steel and Engineering, Ltd., Moorgate, Station Chambers, E.C.2. Price 10s. net. This book incorporates the firm's handbooks 20 and 21, a complete revision of which has been necessitated by further changes in practice and standard specifications. New features of the book are the adoption of the British Standard formula for columns, a chapter on slab bases, up-to-date details of welding practice, and current London building regulations.

The Mining Year Book, 1940. Compiled by W. E. Skinner. London: Walter E. Skinner, 15, Dowgate Hill, E.C.4. Price 20s. net. The new edition of this book, which covers every section of the mining market, contains full particulars of all the world's principal mining companies together with lists of directors, mining engineers, mine managers, &c.

Arc Melting Furnace for South Africa

HEREWITH and on page 328 we illustrate an arc melting furnace recently installed by Birmingham Electric Furnaces, Ltd., at the works of the Chamber of Mines Steel Products, Ltd., Johannesburg. The furnace is used for continuous operation on the melting of steel scrap of all types taken from various mines owned by the company. This scrap includes shoes, dies, balls, wheels, worn-out rock drills, discarded steel cable, and other similar material, and the metal as poured has a carbon content of 0·7 to 1·0 per cent. The main production is billets, which are used for making balls, shoes, and dies. The furnace is one of the makers' standard range of sizes and is operated on a rating of 3600 kVA on 2000 volts, three-phase, 50 cycles, the supply auxiliaries operating on 500 volts, three-phase, 50 cycles. The capacity of 190 cubic feet is sufficient for a charge of 7½–8 tons, and the time required to obtain a clear melted bath from a fully cold charge, with the furnace already hot, is approximately 1½ hours.

Construction of Furnace Body

The furnace is cylindrical in form, with a dished bottom. It is constructed of heavy gauge steel plates, welded and riveted, the rivet heads being ground flat, in order to give a clean external appearance. The casing is heavily reinforced with cast and structural steel members including a heavy, cast steel top stiffening ring which is continuous across the door openings and prevents distortion of the shell by heat. The furnace chamber is of approximately spheroidal shape, thus ensuring minimum heat absorption and minimum radiation losses.

The furnace roof is of arched construction, the refractories being seated in a heavy, channel section steel roof ring which is water-cooled on its outer circumference. The roof ring is designed for easy removal, enabling a new roof to be quickly fitted while the original one is being rebricked. The pouring spout is of heavy cast steel, and is attached to the furnace casing by wedges which permit of its easy removal for lining.

A large door is fitted diametrically opposite the pouring spout for charging and slagging. This door has heavy, cast steel, water-cooled cheeks with machined water-cooled guides. The door is pneumatically-operated, and is self-clamping in the closed position. This special design of door is claimed to reduce heat leakage and therefore to economise electrode consumption.

Charging Arrangements

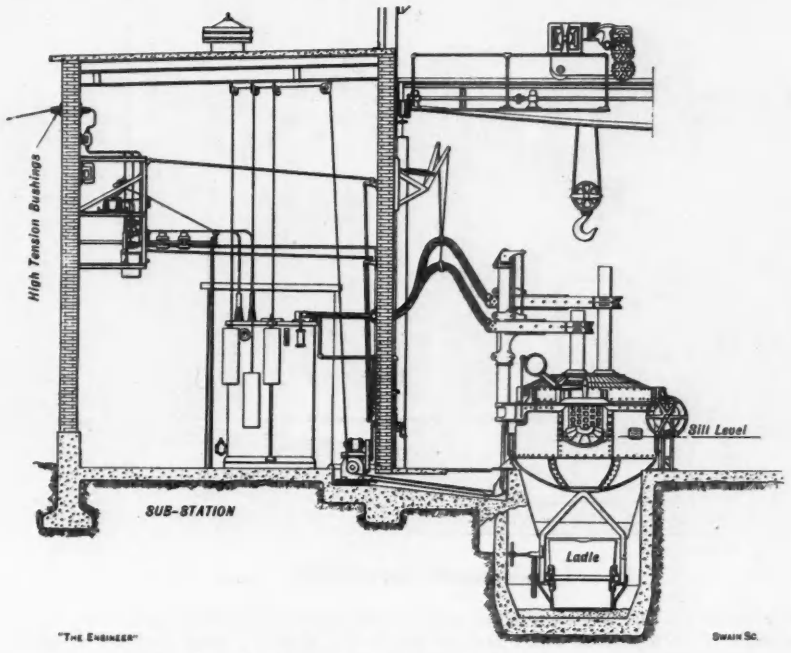
The furnace is arranged for top-charging by means of a drop-bottom bucket. The roof is lifted and swung aside by means of a hydraulic ram situated immediately below the electrode masts and mounted in the furnace foundations. The head of the ram is arranged to engage an eye-casting integral with the furnace roof and carrying the furnace masts. Separate pistons control the lateral movement of the roof.

When the roof is lowered to the working position, it is securely attached to the furnace casing by quick-acting, adjustable clamps and the ram is disengaged, permitting the furnace to be tilted. The tilting and lifting mechanisms are interlocked to prevent the furnace from being tilted when the roof is raised.

Tilting Mechanism

The tilting gear fitted consists of a pair of heavy, cast steel rocker trunnions mounted on each side of the furnace casing, having double-flanged treads running on track frames which incorporate teeth engaging with corresponding teeth on the rockers, to prevent creeping. The rockers provide a wide angle of tilt of 45 deg. forward for pouring, and 35 deg. backward for fettling and slagging. They are designed to maintain the stream of molten metal from the pouring spout in approximately the same vertical line throughout the pouring, eliminating the need for moving the ladle.

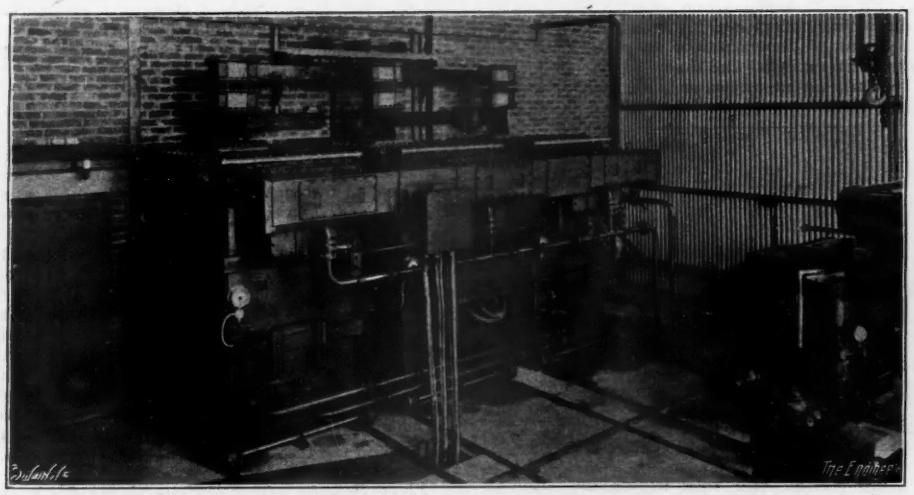
The furnace is tilted by a steel screw engaging with a long nut attached to the furnace casing in swivelling trunnions. The screw thread is suitably lubricated and is encased in a telescopic dust guard. It is arranged for operation either by an electric motor or by a hand wheel. The whole of the tilting mechanism is above ground, and is therefore immune from contamination by slag or dirt.



SECTIONAL ARRANGEMENT OF SUB-STATION AND FURNACE

Electrode Gear

The three graphite electrodes, each 10in. in diameter, project through the roof of the chamber in triangular formation and are automatically moved towards or away from the bath to maintain the required input.



HIGH TENSION TRUCK TYPE CIRCUIT BREAKER

The electrode glands are water-cooled, and are provided with expansion slots to prevent cracking in the event of a failure of the water supply. They are provided with luting rims to facilitate the sealing of the furnace during shut downs. The electrode glands are supported by an insulated clamping device arranged to permit adjustment in three directions and mounted to compensate for the expansion of the roof refractories.

Ths electrode clamps are of cast, high conductivity copper, and are of the wedge type, designed to accomodate over-size or irregular electrodes. These clamps are mounted at the extremities of horizontal arms which, in addition to supporting the weight of the electrodes, are also the means of bringing the current to the electrode and of supplying the cooling water. The arms are of tubular construction and are constructed to give great rigidity and freedom from whip. They are of a design specially developed to minimise losses through eddy currents. The electrode arms are attached to crossheads arranged to slide vertically on steel masts mounted at the rear of the furnace in a heavy steel casting integral with the furnace casing. The carriages are fitted with buffer springs and hardened steel rollers running in anti-friction bearings. The rollers engage with feather keys fitted in the masts, thus providing smooth vertical movement with little friction and no side-sway.

The electrode carriages are suspended on flexible steel cables passing over ball-bearing sheaves, through the tubular masts and through ducts to the winches, the cables being carried beyond the winches to the counterweights. The system incorporates compensating sheaves arranged to prevent movement of the electrodes when the furnace is tilted. The electrode cables are driven by motors, and in order to avoid damage to the electrodes a friction-drive system is incorporated which permits the cables to slip on the drums if the electrodes are obstructed in their movement, either by coming into contact with the charge, for instance, or reaching the top of the mast. This arrangement obviates the use of limit switches.

Electrical Equipment

The electrical equipment comprises the following items :—

High Tension Switchgear.—A main high tension truck type circuit breaker made by the English Electric Company, Ltd., is provided in a cubicle in the substation. The switch is of 150,000 kVA rupturing capacity, fully protected, and provided with a no-volt release coil interlocked with the tap-changing switch on the furnace transformer.

Transformers.—Four single phase, step-down transformers of the oil immersed, indoor type, specially designed for furnace work were supplied by the British Electric Transformer Company, Ltd. These transformers operate as a three-phase bank with one spare unit, for operation on the 2000 volts, three-phase supply. By means of tappings on the H.V. winding, a large range of voltages on the L.T. side can be obtained. Each transformer has a built-in variable reactor. The cooling equipment consists of a Serck cooler, with pumps and motor for circulating the oil.

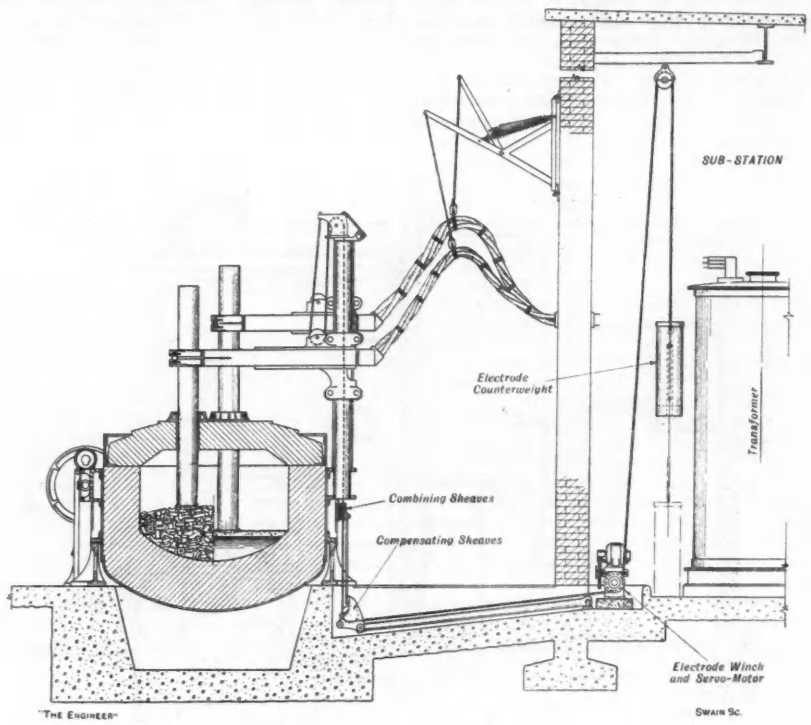
Low Tension Switchgear.—The tilting motor is controlled by a tramway pattern, drum type reversing manual controller, mounted in a convenient position.

Instruments.—The main H.T. switch cubicle is fitted with voltmeter and ammeter, current and voltage transformers, and protective devices. In addition, a three-phase, unbalanced load, integrating kVh meter is provided. A separate instrument panel carries a voltmeter and six-way switch, an indicating kilowatt meter, single-phase ammeters, a synchronous electric clock, electrode regulator control, transformer tapping indicator lamps, and a tapping switch hand wheel.

Electrode Regulator.—Westinghouse automatic electrode control equipment is provided for controlling separately each of the electrodes by means of starting and reversing contactors, through which the winch motors are energised. By a special system, the effect of both current and voltage coils on the balanced armature is automatically reduced when the electrode has been brought by the winch motors close to the desired position. Final adjustment is

obtained rapidly, but with great accuracy, by automatic inching of the winch motors provided under this system.

The furnace can be charged in about five minutes, and the saving of time as compared with a fixed roof furnace is claimed to give considerably improved production. The fact that a larger output is obtainable from a given size of furnace means that power, electrode, and refractory costs per ton of steel poured are notably reduced. The furnace can be charged with scrap right up to roof level, and, moreover, the scrap need not be broken into pieces small enough to pass through the door.



ARRANGEMENT OF ELECTRODE GEAR

Instrument for the Measurement of Heel and Trim*

By T. U. TAYLOR, A.M.I.N.A.

The usual method of measuring the heel of a ship by a plumb line or "pendulum" suspended against a batten is simple and effective, but has some disadvantages. The pendulum is required to be long, and in many cases this means suspending it at a point high up in the ship some distance above the centre of oscillation, with the result that if there is much movement of the ship the movements of the pendulum may be unsteady and confused, and it is difficult to judge the mean position.

It appeared to the author that if the surface of a very small quantity of fluid were used as a "pendulum," and its deflection magnified and measured by observation of the deflection of a beam of light reflected from its surface, some improvement in steadiness might result. A further advantage was evident, in that such an arrangement would give double the deflection in a given height, *i.e.* that deflections equivalent to those given by a 30ft. pendulum could be obtained in a height of 15ft.

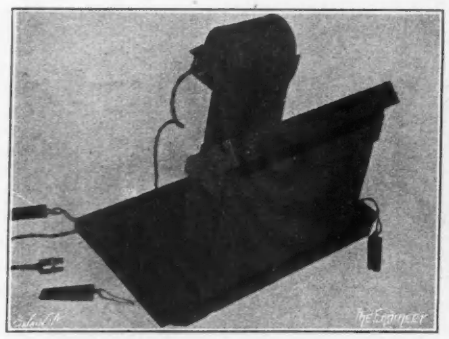
Advantage of this compactness might be taken in either of two ways: (1) the length of "pendulum" might be increased and more sensitive readings obtained; or (2) the fluid reflector might be placed near the centre of oscillation of the ship with a possible gain in steadiness. There would be another incidental advantage as the "pendulum" would be virtually turned upside down, thus allowing the deflections to be observed in an accessible position at or near the deck.

After some experiment an instrument was designed and made for testing on board ship. The fluid reflector actually used is oil. The instrument proper—see illustration—consists simply of a projector for projecting the light beam on to the fluid reflector, and a translucent screen inscribed with a scale on which the reflection is received and the deflection measured. The light beam is projected by focusing an image or shadow by means of a lens. The lens used is an ordinary lantern projector lens of about 2in. diameter and 8in. focal length in a rack and pinion focusing mount of conventional pattern. The image or shadow is produced by means of a small triangular aperture of about $\frac{1}{16}$in. side, with one side parallel to the fore and aft axis of the instrument, and the projection of this side gives the reading edge or shadow on the screen, while the open part of the triangle illuminates the figures on the scale.

The triangular aperture is made from three finely cut strips of opaque paper pasted together and fixed at the correct focal distance from the lens. The image or shadow of this aperture when projected a distance of 30ft. gives a triangle of about 3in. side.

No condenser lens is used, the field to be illuminated being very small, and sufficiently even illumination is obtained from the fact that the filament of the lamp is out of focus, while an intense beam is produced without the use of a special type of lamp. The lamp used is an ordinary 230 volt, 60 watt, gas-filled Osram coiled coil lamp, the bulb being clear. This lamp is arranged in a horizontal position with the filament along the fore and aft axis of the instrument, the effect being to stop down the lens slotwise, *i.e.* only a narrow strip across the centre of the lens is used. This gives sufficient definition on the reading edge of the shadow to read the scale with ordinary slide-rule accuracy, *i.e.* to about 0·01in. to 0·02in. The oil reflector is carried in a small container $2\frac{3}{4}$in. in diameter and $\frac{1}{4}$in. deep. This container is filled to a depth of about $\frac{1}{8}$in., the oil used being a light lubricating oil. Three rubber studs are fixed to the underside of the container and three to the underside of a small baseboard on which it is mounted, to insulate from vibration. A small metal screen is placed around the container to protect the oil reflector from draughts and dust.

The translucent screen on which the reflection is received is enclosed in a box with a narrow slot in the bottom to admit the reflected beam, and a similar slot in the top for viewing the shadow or reflection on the screen. The screen is made of tracing cloth and is supported half-way up inside the box, which is about 9in. deep. The inside of the screen box, the inside of the reflector container, and the whole of the outside of the instrument are painted with flat black paint to minimise the reflection of light from sources other than the oil reflector. The projector and the box containing the screen are mounted together on a baseboard, the level of which can be adjusted by means of three wedges. The instrument is supported above the oil reflector and the light beam is projected downwards so that the reading edge of the triangular image strikes the reflector at its centre and along its fore and aft axis, and is reflected from thence on to a centre mark on the screen. The reflected image is then sharply focused on the screen by means of the rack and pinion adjustment in the lens mount. The screen is marked with a scale in inches and tenths and is $5\frac{3}{8}$in. long on each side of the centre mark.



HEEL AND TRIM INDICATOR

A detachable hood with an inclined mirror can be fitted over the upper slot in the screen box so that the scale may be read horizontally if head-room is limited.

The first test on board ship was carried out during the inclining experiment on a large cargo liner, and the virtual length of pendulum was 24ft. $5\frac{1}{2}$in., the screen being 12ft. $2\frac{3}{4}$in. above the oil reflector. Two ordinary pendulums were used, each 39ft. long, the forward one in No. 2 hold and the after one in No. 5 hold. These pendulums were arranged in the usual way with the bob immersed in a trough of oil to damp the swing, and were suspended at points about 44ft. above the keel. The heel indicator was set up in the after end of the bridge 'tween decks over a small trimmers' escape hatch to the 'tween decks over deep tank. The height of this 'tween decks is 10ft. 10in. beam to beam. The support for the instrument consisted of two $2\frac{1}{2}$in. planks bolted to small angle lugs tack welded to the coaming of the hatch, with a space of $13\frac{1}{2}$in. between the planks transversely. The support was levelled transversely to allow for camber of deck, the escape hatch being about 20ft. to port side of the centre line of ship. In the 'tween decks immediately under the hatch a square board about 2ft. by 2ft. was placed to level off the camber of the deck. The reflector base board and oil reflector were placed on this board, the reflector being about 26ft. above the keel, and the instrument mounted on the supports above. The experiment took place at night and there were a number of lights in the 'tween decks above and below the instrument. There was no difficulty in adjusting the instrument with all lights on, one lamp being nearly over the instrument and one over the reflector. During the experiment all lights near the instrument and reflector were switched off. There was no difficulty in reading the scale, the reflection being very bright and sharp.

The instrument gave steady and consistent readings, and the result was almost an exact mean of those for the two ordinary pendulums.

This first test showed that the instrument would function as a very much longer "pendulum" and on the next test accordingly the length was increased by 50 per cent., the virtual length of pendulum being 37ft. 3in., *i.e.* the screen was 18ft. $7\frac{1}{2}$in. above the oil reflector. The test was carried out during the inclining experiment on a large oil tanker.

As a result of the experience gained in the second test it was considered that the instrument would function under the same conditions as a 50ft. pendulum. It was accordingly arranged to test this. The virtual length of pendulum as actually arranged on the ship was 54ft. $10\frac{1}{2}$in., or about 50 per cent. longer than in test No. 2, the screen being 27ft. $5\frac{1}{4}$in. above the oil reflector. This test was carried out on another large oil tanker. The arrangements were generally similar to those in test No. 2, but the staging for the oil reflector was placed on the tie beams to a lower stringer about 27ft. below the instrument and about 11ft. above the keel, the tank being about 38ft. deep. Very satisfactory results were obtained. The maximum deflection measured on the instrument was 5·35in., compared with 3·55in. on an ordinary pendulum 36ft. long.

Conclusion

It was expected that the oil reflector would prove rather steadier than the normal pendulum, and from the tests so far carried out the impression is gained that this is the case. An effort was made to obtain evidence of this by noting the amplitude of swing on the instrument and on one of the pendulums at the time of taking readings, but it was not possible to synchronise these observations.

It may be added that the instrument has functioned perfectly throughout the tests. It was set up and adjusted in about ten minutes before the commencement of each experiment and the readings were taken quickly and without elaborate care by taking the mean of a few oscillations. No special arrangements were made at the ship beyond those mentioned in the paper, and the tests were carried out generally under ordinary shipyard conditions.

Fluid Reflector.—The obvious choice for a fluid reflector would be mercury. It was thought, however, that mercury would not be ideal in some other respects and no experiments were made. Water and oil are obviously not ideal as reflectors, but some experiments were made with these and with glass which appears to reflect about the same amount of light. This amount was not measured, but was roughly estimated at from 5 per cent. to 10 per cent. of the light projected on to its surface. Oil appeared to be slightly better than water as a reflector, possibly because its surface is less liable to be flawed by minute particles of dust and dirt. Oil has the further advantage of being less affected by draughts and vibration, and is better damped considered as a "pendulum," while some control can be exercised over the degree of damping by the choice of an oil of suitable viscosity. Oil has been used as the reflecting fluid throughout the experiments on board ship.

* Institution of Naval Architects. Spring, 1940. Abstract.

Container for Fluid Reflector.—It was desired to make the fluid reflector as small as possible.

Although not exactly measured, it was found by experiment that there was no flat reflecting surface in a container less than about 1in. in diameter, *i.e.* due to surface tension the surface is concave for about ¼in. in from the edges. The method of projecting the light beam by means of a lens requires a minimum flat reflecting surface of half the diameter of the lens, otherwise the restriction in flat reflecting surface has the effect of stopping down the lens. A further margin is required in order to get a reasonable length on the reading edge of the shadow, and to allow for some slight error in the adjustment of the light beam. The actual container used is 2¾in. in diameter and the flat reflecting surface is therefore about 1¾in. in diameter, which gives about ¾in. margin on the minimum size of container necessary for the lens used. The lens being virtually stopped down slotwise along the fore and aft axis of the instrument, the transverse width of the container could in theory be reduced. This was not done as it was felt there was some risk of slight disturbances at the edge of the container due to the motion of the ship being transmitted to the reflecting surface.

Fluid Pendulum.—Some experiments were made with fluid reflectors to determine the period of oscillation and degree of damping. The fluid reflector was placed under the instrument 3ft. 9in. below the screen, giving a virtual length of pendulum of 7ft. 6in.

The container was tilted about 5 deg. and then dropped, and the period of oscillation and time of damping noted. The figures are given below.

The times are approximate.

	Reflector	Period of Single Oscillation	Time of Damping from 5 deg. Tilt
		sec.	sec.
1	Water ⅛in. deep in 2¾in. dia. container	½	5–7
2	Water 2in. deep in 2¾in. dia. container	½	45–60
3	Oil (light lubricating) ⅛in. deep in 2¾in. dia. container	2+½	2½
4	Oil (heavy lubricating) ⅛in. deep in 2¾in. dia. container	15+0	15

NOTE.—Oil reflector (3) made two oscillations only before coming to rest, one of about 2 seconds and one of about ½ second.

Electricity Supply at a Gloucester Works

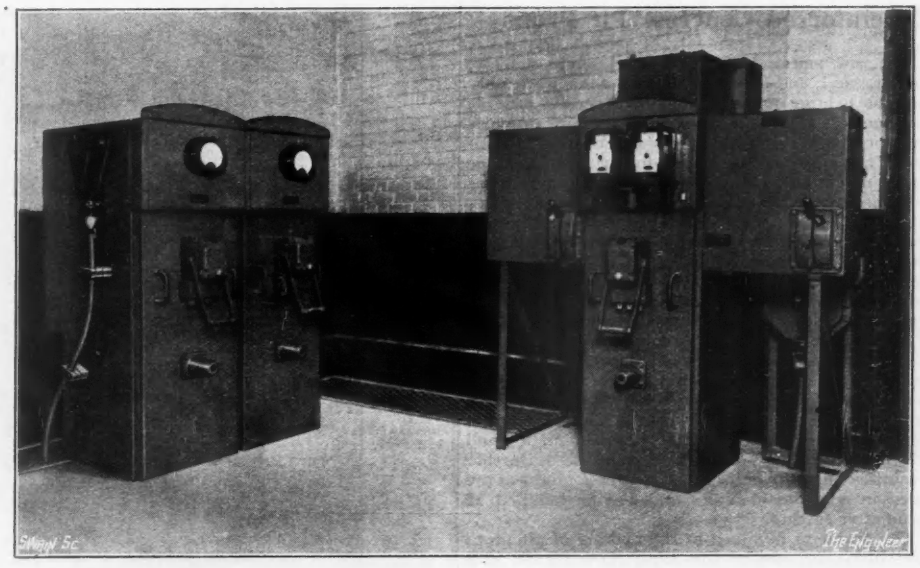
AN interesting installation has just been completed at the works of Fielding and Platt, Ltd., of Gloucester, where factory reconstruction and extension became necessary to cope with the increasing demand for hydraulic presses and oil engines. Until recently the supply for operation of machine tools and factory services was obtained from a reciprocating engine driving a D.C. generator, with a secondary low tension A.C. supply from the Gloucester Corporation. The installation of new multiple unit machine tools with individual drive and large testing equipments meant that a new A.C. service was required, and arrangements were made to take an E.H.T. bulk supply from the Corporation for the whole of the factory requirements.

A contract was placed with the Brush Electrical Engineering Company, Ltd., of Loughborough, for the supply and erection of the whole of the substation equipment required, namely the E.H.T. bulk supply ring main switchgear, E.H.T. and M.T. control boards, transformers, a motor-generator set with liquid starter and new D.C. switchgear. The accompanying engravings illustrate the interior of the completed new substation.

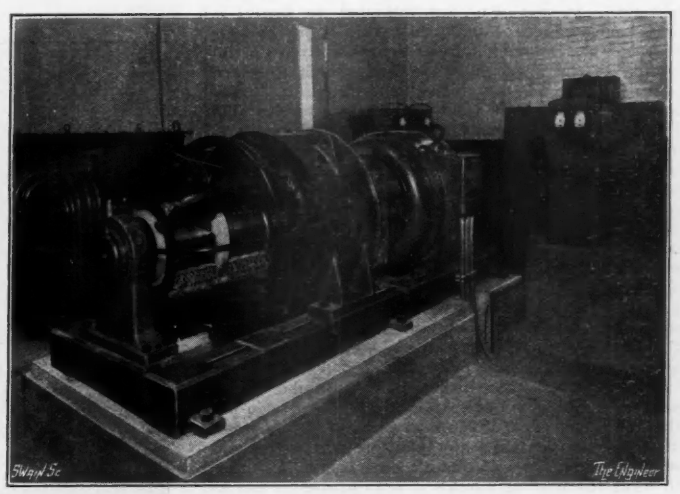
The E.H.T. switchgear is of the Brush company's vertical isolation metal-clad air insulated type, incorporating oil circuit breakers of 150 MVA rupturing capacity, and the ring main isolating switches are of the oil break extensive type for future additions. There are two 350 kVA three-phase, 50 cycle indoor pattern transformers, ratio 10,500/400 volts, oil immersed natural self-cooled tappings being provided on the H.T. side for plus and minus 2½ per cent. and 5 per cent. variation in the H.T. voltage. The tanks are of the boiler plate tubular type mounted on rollers, the H.T. side being provided with a cable box and on the L.T. side terminals are mounted in the tank side and protected by a sheet steel cover fitted with entrance bushes for the outgoing cables. The transformers are designed and constructed in accordance with B.S.S. 171–1936 and arranged for star connection with the neutral point brought out on the L.T. side.

The motor generator set which was installed to keep all the existing D.C. plant going without alteration comprises a 200 kW, 110 volt, 1820 amp. generator driven by a 300 H.P. 400 volt slip-ring induction motor. The generator is of the protected type arranged with pedestal roller bearings at the commutator end and an end shield bearing at the fan end. The construction is of the Brush standard design and the commutator and brush gear are built in accordance with the company's commutator experience. A notable feature of the design is the tandem brush holders staggered to ensure perfect commutation under all conditions of load, and to maintain even commutator wear. Mechanical rigidity of the long commutator is obtained by a shrunk ring fitted centrally upon the commutator. The slip-ring induction motor is of the screen protected type, a Brush standard product built and designed to comply with B.S.S. 168–1936. This motor is controlled from the 400 volt A.C. switchboard and by a Brush liquid rotor starter.

The medium tension A.C. switchgear is of the stationary sheet steel cubicle type, incorporating oil circuit breakers and gang-operated isolating switches. This switchboard has been built by the Brush company and alongside it is an ironclad distribution board manufactured by H. Holmes and Co. A D.C. switchboard by the Brush company controls the output from the M.G. set and two main feeder circuits. The whole of the interconnecting cables for this plant was installed by the West Gloucester Power Company.



SWITCHGEAR CUBICLES



MOTOR-GENERATOR SET AND SUB-STATION EQUIPMENT

Engineer Training

ONE of the most comprehensive training schemes in force in this country is that of the British Thomson-Houston Company, Ltd., which has just issued a new and liberally illustrated edition of an attractive sixty-page brochure entitled Engineering Training. It opens with some interesting historical details of the B.T.H. company, followed by particulars of the firm's activities and achievements in its works at Rugby, Coventry, Birmingham, Willesden, and Chesterfield. The remainder is devoted to the system of apprentice training at these centres. In the selection of trainees educational qualifications are regarded as the starting point only. Subject to the minimum demand being satisfied, acceptance is, in the final resort, determined by personal interview, at which very high value is placed on personality, character, and promise of practical competence. Youths are received from the universities, technical colleges, public or secondary schools, as well as from the central and elementary schools, and are trained for various positions in the company's service, and that of its customers, covering all grades from the technical engineer to the skilled craftsman.

The following courses are provided:

(*a*) Student course—for university and college graduates.

(*b*) Engineering course—for youths with London matriculation or its equivalent.

(*c*) Drawing office course—for youths with school certificate.

(*d*) Trade, works, office, or clerical courses—for boys with a good general education.

The company makes a point of encouraging ability in whatever sphere it reveals itself, and it annually raises the status of boys of proved ability by transferring them to higher courses. It has never accepted

premiums for any of its courses, being of the opinion that a boy of ability should not be handicapped by such financial consideration, and that this policy is in the best interests of the industry.

The brochure sets out in detail the various stages of the courses mentioned above, giving the periods of training and rates of pay, which, for indenture apprentices are suitably graded depending upon commencing age and training course accepted. In addition to annual increments there is a service bonus awarded for satisfactory progress, and a supplementary bonus awarded for success in the examinations of the local technical college. Parents who are wondering what to do with their sons might easily do worse than ask the British Thomson-Houston Company, Ltd., Rugby, for a copy of this little book.

Reinforced Concrete Pit Props

The raw materials for making concrete, namely, cement, sand, and gravel or broken stone are readily available in large quantities and in view of the possible shortage of timber and steel for mine supports attempts are being made to develop the use of reinforced concrete props. A preliminary study of the factors involved in the manufacture of such props was published by the Mines Department early in December in which the importance of using high-strength concrete and adequate reinforcement was emphasised. This report was based on the use of hand mixing and hand placing as might be practised on a small scale at individual collieries, but attention was subsequently drawn to the advantages of mass production methods as used by pre-cast concrete manufacturers.

In a typical pre-cast concrete factory the raw materials are mixed in a power-driven mixer, placed in metal moulds and compacted by vibration. These methods yield more uniform results and in general a higher strength than could be obtained in a hand mix with the same quantity of cement. A further advantage in many cases is that the cast products are cured in a steam chamber and can be handled 12 hours after casting.

The problems involved in the making of pit props have been discussed by the Mines Department with a number of the manufacturers of pre-cast concrete products and in the light of these discussions many manufacturers have made sample props which have been tested at the Safety in Mines Research Board Laboratory, South Kensington, or at other laboratories using a standard method of test. These tests establish that high grade reinforced concrete pit props can be produced in quantities under normal commercial conditions.

A specification has been prepared covering the requirements as to materials, manufacture, and tests, to ensure the supply of props of satisfactory quality. Copies of the full specification may be obtained on application to the Director of Mining Supplies (Mines Department, Mill House, 87–89, Shaftesbury Avenue, London, W.1), and colliery companies proposing to make use of concrete props should insist that they comply with the specification.

The opening clauses of the specification relating to materials, mixing, &c. are intended to secure a reasonable degree of uniformity in the product so that samples tested shall be representative of the quality of the batch of props from which they are taken. These clauses follow the lines of B.S.S. No. 607–1935 "Reinforced Concrete Poles for Electrical Transmission." The amount of reinforcement required is approximately 8 per cent. of the total weight of the prop if in mild steel, or the equivalent in high tensile steel. This reinforcement is to be half in the form of longitudinal rods to give sufficient mechanical strength to allow the prop to be handled, and half in the form of a spiral to prevent sudden and violent failure. The crushing strength of the concrete must be sufficient to enable the prop to withstand a crushing stress of at least 4480 lb. per square inch on the cross-sectional area measured to the outside of the spiral, with a reduction for slenderness in the case of long props.

It is realised that although the circular cross-section of timber props is the most convenient in use this shape may be difficult to produce in concrete, and the specification allows for props of octagonal section, or square with chamfered corners. In order to limit the cost of moulds it is desirable to use as few sizes of concrete prop as possible and to this end the specification proposes that the whole range from 2ft. to 6ft. 3in. in length should be covered by six diameters with three standard lengths to each diameter, making 18 sizes of prop in all. The specification also gives in full details of the method of test for props to be tested in the laboratory, and of a drop test which can be carried out without the use of any special testing machine.

The American Steel Industry.—According to statistics compiled by the American Iron and Steel Institute from figures supplied by 150 companies representing over 95 per cent. of the steel making capacity of the United States, nearly 166 million dollars are to be spent on new equipment during 1940. Of the estimated 126 million dollars to be spent on new equipment during 1939 orders were placed for 121 million dollars worth of plant.

Oil Engine Driven Arc Welder

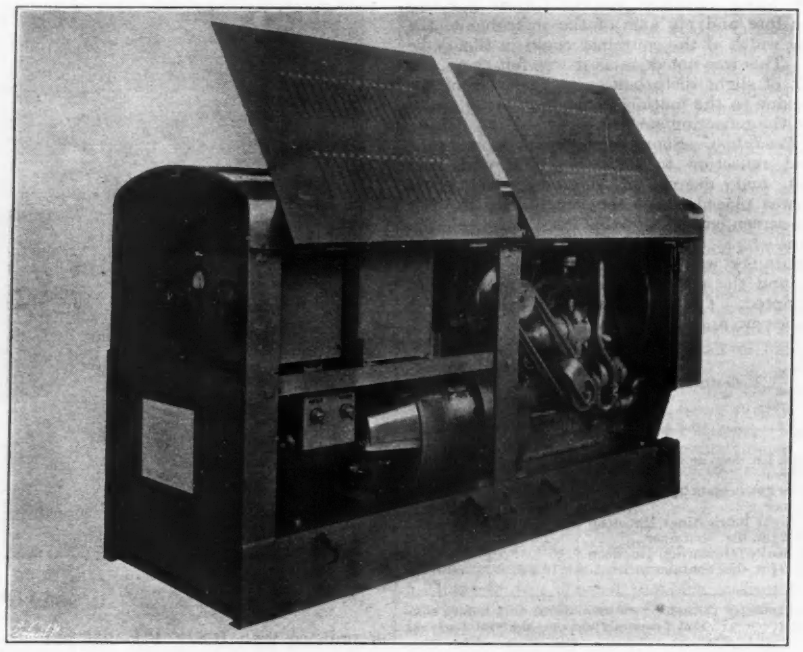
A new 300 ampere continuous rating oil engine driven arc welder, equipped with petrol engine starting, is now being made by the Lincoln Electric Company, Limited, Welwyn Garden City, Herts.

The petrol engine used for starting the welder is mounted above the main unit and is started by means of a hand crank. A belt drive, engaged by means of a clutch, connects the starting engine to the oil engine. Starting in cold weather is facilitated by the fact that the cooling system of the small petrol starting engine is connected with that of the main engine. This arrangement makes it possible to warm up the oil engine by running the starting engine a short time and allowing the heated water to circulate through the two cooling systems. The auxiliary petrol engine and the belt drive which connects it to the main diesel engine can be clearly seen on the accompanying engraving.

The generator has a current range up to 400 amperes for welding duty, with a maximum voltage of 40 volts at the arc, the output of 16 kW being ample for operating electrodes up to $\frac{5}{16}$in. and $\frac{3}{8}$in. in diameter.

The arc welding generator is a standard Lincoln "Shield-arc" unit equipped with self-indicating dual continuous control, polarity reversing switch, and voltammeter, and fitted with a separate exciter to give adequate reserves of power. The self-indicating dual continuous control makes possible the independent adjustment of both voltage and current, so that the right type of arc and the right heat at the arc are immediately available for all welding applications, so as to ensure the fast and economic production of high quality welds.

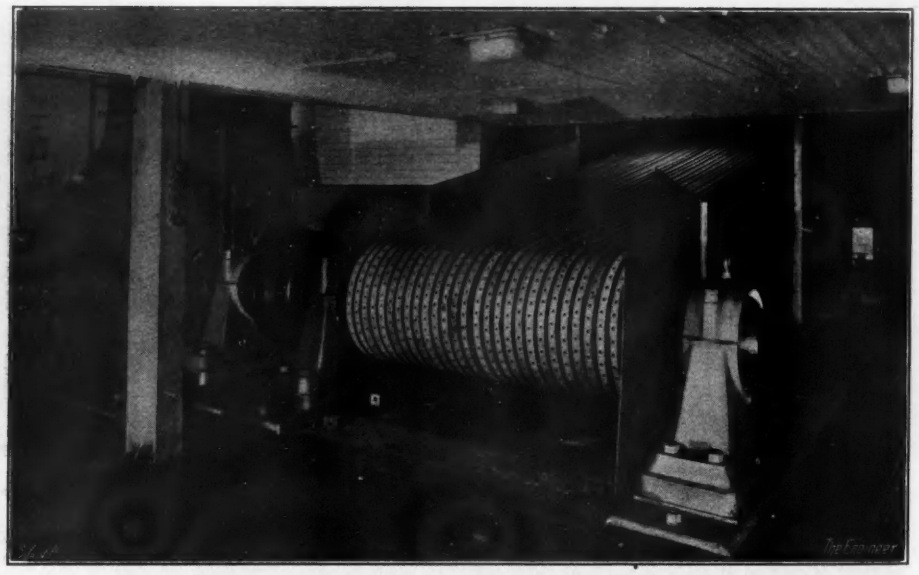
The frame of the arc welding generator is attached directly to the oil engine housing and the generator shaft is connected to the engine flywheel by a special type of flexible coupling. Mounting for the entire unit is provided by a substantial channel frame, and it can be completely enclosed by hinged cover-plates.



OIL ENGINE DRIVEN ARC WELDER

Short-Centre Rope Drive

An interesting short-centre rope drive has recently been installed at the works of Brown Bayley's, Ltd., Sheffield. It drives a tyre bending mill from a 1400 H.P. motor which is capable of a hundred per cent. momentary overload. The torque to be transmitted is nearly constant, 6½ ton-metres up to 150 r.p.m. and slightly less between 150 r.p.m. and 175 r.p.m. The motor pulley is 30in. diameter, that on the mill being 90in. The centres are at 15ft. The pulleys are grooved to take twenty-eight 2in. ropes and are designed to take the peak load of 2800 H.P. The ropes are of vee section and are known as "Dixel" ropes. The driving unit, both pulleys and the ropes, were designed and supplied by R. and F. Dick, Ltd., and the ropes were installed by their fitters on site. The mill works continuously throughout the twenty-four hours. The operation performed takes about ten minutes and therefore the driver has to start the mill from rest six times every hour.



SHORT-CENTRE ROPE DRIVE

Mine and Quarry Accidents.—A preliminary statement of the Mines Department shows that the number of deaths through accidents at the mines and quarries of Great Britain during 1939 totalled 875, of which 772 took place in mines under the Coal Mines Act, 1911.

Obituary

WILLIAM BRADLEY WOODHOUSE

THE British power supply industry has lost one of the outstanding figures of recent years by the sudden death on Sunday, March 31st, at his home at Bramhope, near Leeds, of William Bradley Woodhouse, who for the last thirty-seven years has been associated with the Yorkshire Electric Power Company as its chief engineer and managing director. He was born in London on April 3rd, 1873, and was educated at Finsbury Technical College. On leaving college he spent some time in the coal mining industry in the Midlands and in South Wales, and then returned to London to begin his engineering training with the India Rubber Company of Silvertown, at the same time studying at the University College of London. Later he was engaged on engineering work with John Davis and Sons, and the Cork Electric Tramways and also with Marks and Clerk. In 1896, he was appointed lecturer in mechanics and mathematics at Finsbury College under the late Professor Dalby, a position which he held until 1900, when he went north to join the staff of the Newcastle-upon-Tyne Electric Supply Company under Mr. Charles Merz. Later he was appointed

W. B. WOODHOUSE

resident engineer to the company, a position he continued to hold until 1903, when he went to Leeds to take up the position of chief engineer and manager of the Yorkshire Electric Power Company. He saw that undertaking grow from comparatively small beginnings to the very important position, which to-day it holds, in the electric supply industry, and to him and his pioneer work it owes much, both as regards its progress and its development.

His work in Yorkshire was marked by its bold lines and personal initiative, alike as regards the generation and the distribution of electric supply for lighting and power. In his first schemes Woodhouse employed three-phase four-wire distribution at a pressure of 400 volts, with an intermediate distribution pressure of 5000 volts at 50 cycles. As early as 1904 he adopted the practice of formulating the maximum demand charge in kilovolt-amperes, which later was widely adopted. His mining experience gave him a keen understanding and interest in all fuel problems, and he was one of the first power supply engineers to introduce a coal clause into his agreements.

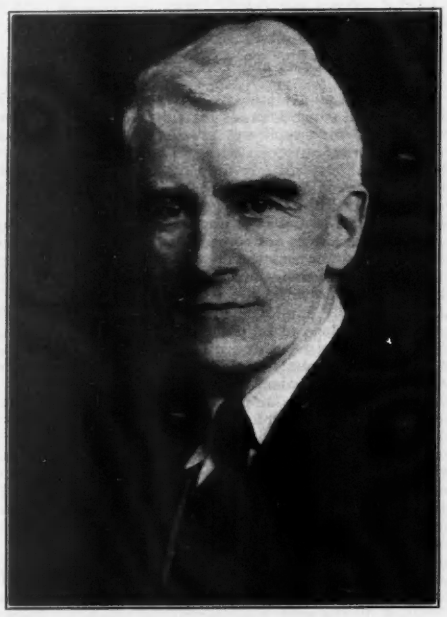
The use of coke-oven gas attracted his attention, and in 1913 he began to harness the supply of surplus coke-oven gas, a practice which was extended and developed by a subsidiary company of the Yorkshire Electric Power Company, the Yorkshire Waste Heat Company. For many years he was a member of the British Association Fuel Economy Committee, and he was closely acquainted with developments in coal carbonisation both by the high and the low temperature processes. One of the founder members of the Electrical Development Association, he did much to extend the economical generation and distribution of electricity for domestic and industrial uses. In the last war, Mr. Woodhouse was electrical advisor to the Coal Controller of Yorkshire. He was a member of the Council of the Association of Power Companies, and the evidence he gave on supply and distribution helped to frame the Electric (Supply) Act of 1919. He was a member of the Institution of Civil Engineers, the Institution of Electrical Engineers, and the Institution of Mining Engineers. For some years he was chairman of the North Midland Centre of the Institution of Electrical Engineers, and was a valued member of council, serving as vice-president, and President, an office which he held with distinction from 1923 to 1924.

In his addresses to the North Midland Centre he dealt with the leading characteristics of supply undertakings, such as fuels and the generation of electricity, and also distribution and tariffs. These subjects were elaborated in his presidential address of October 23rd, 1924, and sections on legislation and problems of interconnection were also added. His papers read before the Institution of Electrical Engineers, included those on "Overhead Electric Lines," and "Distribution of Electricity," while he contributed a further paper to the British Association on "Protective Devices for Power Systems."

He was a member of the Section Electrical Committee of the British Standards Institution, and the Electrical Research Association.

PROFESSOR STEPHEN MITCHELL DIXON

ENGINEERING students of 30 years ago, in all parts of the world, will learn with regret of the death, at his home in Nice, of Professor Stephen Mitchell Dixon, who retired in 1937, and went to live in the



PROFESSOR DIXON

south of France. Professor Dixon was of Irish descent and was born in Dublin in 1868. He was educated at Rathmines School, and Trinity College, Dublin, from which he graduated Senior Moderator in Experimental Physics. Coming to London in 1890, he joined the staff of Lovatt and Co., and was engaged on work connected with the Kings Cross and Redhill Tunnels. In 1902 he was appointed Professor of Civil Engineering in the University of New Brunswick, where he remained for two years, and then went on to the Dalhousie University, Nova Scotia. In 1905 he returned to England, and was invited to take the chair of Civil Engineering at the University of Birmingham, becoming in 1912–13 Dean of the Faculty of Science in the university. In 1913 he became Professor of Civil Engineering at the Imperial College, South Kensington, and remained in the University of London until 1933, serving as Dean of the City and Guilds Engineering College from 1930–33.

During the last war he was personal assistant to the late Sir Henry Fowler, who was Director of Production at the Ministry of Munitions in the early part of the war, but in 1917 he went to France with the Royal Engineers as a Lieutenant, and was promoted to the rank of Captain in 1918. He was keenly interested in mining work, and from 1923 to 1935 he was a valued member of the Safety in Mines Research Board. He also carried out extensive researches in connection with the use of concrete and wire rope. He was a member of the Institution of Civil Engineers, and for some time practised as a consulting engineer. Professor Dixon was at one time a well-known contributor to scientific journals, THE ENGINEER amongst them. The natural abilities with which he was gifted were associated with a personal charm which endeared him to his friends. It is a good many years since he left this country and London was the poorer without him.

New Steel Distribution Scheme

THE new scheme to ensure the equitable distribution of steel supplies brings all the consuming interests into groups under Government departments, which in conjunction with the iron and steel control will be responsible for the supply of finished steel to the services covered by the departments. For the purposes of identification each department has been given a symbol. Below we give the departments with the services covered by each, and the symbol of identification. Consumers may obtain copies of the scheme post free on application to the Registry, Iron and Steel Control, Steel House, Tothill Street, London, S.W.1.

Symbol	Departments and Services Covered	
H.O.	Home Office	Home Office services, *e.g.*, prisons, police, approved schools, &c.
A.R.P.	Ministry of Home Security	Requirements for camouflage, screening blast furnaces, &c. Steel for A.R.P. (including Scotland).
Ad.	Admiralty	Navy requirements.
Ad.M.	Admiralty	Mercantile shipbuilding and repairs.
W.O.	War Office	B.E.F. requirements, army buildings, medical stores, fuel, and light.
M.S.	Ministry of Supply ...	All other requirements for army. Machine tools, small tools, and gauges.
F.	Ministry of supply ...	French Government requirements, direct or indirect.
A.M.	Air Ministry	Air Ministry requirements.
S.D.	Scottish Depts.	Schools, hospitals, housing schemes, police stations, prisons, special areas factories, agricultural buildings, land drainage works, piers, &c., water supplies, sewerage.
B.T.(1)	Board of Trade	(1) Gas undertakings.
B.T.(2)		(2) All home civil requirements except where specifically included under another department.
B.T.(3)		(3) Miscellaneous agricultural requirements other than agricultural machinery and buildings.
B.T.(4)		(4) Indirect exports (*i.e.*, exports of finished goods) excluding requirements of B.E.F. and oil companies and French Government requirements.
B.T.(5)		(5) Direct exports (*i.e.*, exports of finished steel as listed in Appendix "A") excluding requirements of B.E.F., India, and oil companies and French Government requirements.
B.E.	Board of Education ...	Schools.
M.H.	Ministry of Health ...	Ministry of Health services, *e.g.*, hospitals and housing schemes, water supplies. sewerage.
A.F.	Ministry of Agriculture and Fisheries	Agricultural machinery, including Scotland. Agricultural buildings and land drainage works, excluding Scotland.
M.T.	Ministry of Transport	Railways (including all wagons used on railways), ports, canals, highways, tramways, works, and buildings for Ministry undertakings. Motor vehicles and trolley vehicles, gas producers for motor vehicles.
M.F.	Ministry of Food ...	Provision of tins and packing material for food including food for service requirements. Food factories and buildings for storage and distribution.
O.W.	Office of Works ...	Certain new factories and buildings and internal requirements therefor. Certain Government stores and equipment. Fire-fighting appliances.
P.O.	General Post Office ...	Post Office requirements.
M.D.	Mines department ...	Requirements of all mines and quarries.
P.D.	*Petroleum Department	Oil companies' requirements both home and export.
E.C.	*Electricity Commissioners	Electricity supply industry covering generating stations, the grid and distribution systems.
N.I.	Northern Ireland ...	All public services for Northern Ireland.
Ind.	*India	All finished steel as listed in Appendix "A" for direct export.

* For the purpose of this scheme these are regarded as a Government department.

NOTE.—"(B)" added to symbol of any department represents allocations to buildings.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer.

Steel for Goods for Export

Under the new scheme for the distribution of steel supplies, the Board of Trade will allot a tonnage of finished steel for the manufacture of articles for export, excluding, however, the requirements of oil companies, the British Expeditionary Force, and the French Government. The Iron and Steel Control will make the arrangements for this trade except in such cases as the arrangements are made with organised industries. Licences for finished steel will be issued by the Iron and Steel Control for consumers making goods for export and will bear the Board of Trade symbol (see page 337) reference number and period numbers with tonnages for each period. The Board of Trade has issued the following announcement with regard to this class of business: "As from April 1st, under the new scheme for the distribution of steel supplies, the Board of Trade will be responsible in consultation with the Iron and Steel Control, for the allocation of steel required for the manufacture of goods for export. The issue of steel will be greatly facilitated and delay will be avoided where an export group is established for a particular trade, and satisfactory arrangements have been made with the Board of Trade for the administration by the group itself of a global allocation of material in substitution for the present system of individual applications for licences to the Iron and Steel Control. While it is recognised that the April to June quarter must be regarded as a transitional period for the purpose of operating the new scheme, the Board of Trade considers it necessary to warn manufacturers that it is its intention that after the end of June the steel allocation for the export of manufactured goods should, in the national interest, be distributed through Export Groups, and that they will find it progressively more difficult to justify release of material to firms not so organised. It is therefore very important that manufacturers should join such Groups as soon as possible and that the Groups should have allocations arranged with the Board of Trade well before that date. For the period April to June, licences for steel required for the manufacture of goods for export which are not yet covered by special arrangements with organised groups will continue to be issued by the Iron and Steel Control, to whom applications should be submitted direct, but as soon as a group is ready with its total requirements contact will at once be made with the Board of Trade even within the period April to June."

The Pig Iron Market

The sustained effort to expand the production of steel has called for additional quantities of basic pig iron and scrap. To some extent the problem has been met by imports of basic iron, whilst the scrap situation has been relieved by the importation of several cargoes of American material. Even so, however, the steelworks are somewhat anxious regarding their future supplies, and it is evident that all the basic pig iron now being produced is passing immediately into consumption. In most of the producing districts attention is concentrated chiefly upon this class of iron and the output must be at an extraordinarily high level. In the hematite market conditions are also becoming rather tight, as in addition to the rising demand from the steelworks many of the engineering plants engaged upon war work are large users of this quality. Generally speaking the production seems sufficient to take care of the specifications against contracts already entered into, but there is difficulty in placing new orders for reasonably near delivery. The stocks in the makers' hands, which even at the end of last year were considerable, are now, it is understood, largely depleted. In the foundry iron market the position is different. Low phosphoric iron is in active request by the engineering foundries. On the other hand the demand for high phosphoric iron is not nearly so insistent. Gradual progress is being made in bringing the light castings foundries into the war effort, but in many instances these foundries are not working more than three or four days a week. The recession in the building trade is largely responsible and unless some of these establishments can be put upon war work there seems little likelihood of any revival in the demand for high phosphoric iron. One of the features of the foundry iron market is the absence of Cleveland iron. The producing works on the North-East Coast are engaged upon the production of basic and hematite, and users of foundry in that area are now dependent upon supplies of Midland irons. In the Midlands also the demand is chiefly for low phosphoric brands and the production of this quality is barely sufficient to meet users' requirements. Steady quantities of high phosphoric iron, however, are passing into consumption. In Scotland the blast furnaces are chiefly engaged upon steelmaking iron, and the output of foundry qualities is fairly well taken up, although it is said that in some cases considerable stocks exist at the producing works.

Scotland and the North

Interest is greatly concerned with the new scheme for the distribution of steel. The general view is that it is a well considered measure and may have the desired result in easing the pressure upon the steel industry and at the same time enable consumers to obtain more regular deliveries of the material they require. The scheme comes into operation on April 1st, and so far there has been no change in the position. All departments of the works have had to meet incessant pressure from consumers for deliveries and many of them are considerably in arrears against contracts. There has been a decline in the volume of new business, principally because the steel makers have been anxious to avoid adding to their already congested order books. It is understood that there has been an improvement in the supplies of raw materials, and the output of steel is now at an extremely high level. The demand for all kinds of structural material is maintained to an extraordinary degree and the market has been full of fresh inquiries, many of which have not matured owing to the long periods required for delivery. Consumers have now to search the market to find a works able to satisfy their requirements. In cases in which near delivery is an urgent necessity efforts are made to meet the circumstances, but an order must have very strong backing to obtain prompt attention. Angles, plates, and joists are required alike by the constructional engineers and the shipyards in huge quantities, and it is to the credit of the steelworks that they have been able to maintain their rates of delivery as well as they have. The situation in the plate market is causing some concern. All the mills are working at capacity, but the works are slipping behind in the race to keep production in line with demand. In these circumstances it seems hopeless to anticipate that any worth-while quantities of steel can be made available for export. It is hoped, however, that under the organisation of the new scheme it will be possible to revive the export trade by the careful allocation of supplies. Locomotive builders and tank makers are fully employed and their requirements of steel plates, chiefly of the thick and medium descriptions, are growing rather than the reverse. The re-rolling works in Scotland are turning out large quantities of small angles, small bars, and strip. The position in this branch of the industry has improved considerably during recent weeks owing to the importation of large tonnages of semis, but even so some of the works are not so well off for supplies of billets as they would wish. The Lancashire market has been quieter of late, largely because of the difficulty of placing orders rather than from any slackening in requirements. There has been a strong demand for bars and sectional material, whilst the locomotive engineers, boiler, and tank makers have found it difficult to obtain full supplies of plates. The call for alloy and special steels continues unabated and there is a strong request for bright drawn steel bars.

North-East Coast and Yorkshire

With all available plant in operation, and in spite of the careful supervision of distribution by the Control, the pressure for supplies is greater than the steelworks in this district can cope with. The work in hand and offering is almost entirely for Government Departments, and has, therefore, claims to priority; but when all orders come within this category the question of priority becomes difficult and it is obvious that the new scheme for distribution does not come before it was badly needed. For the last few weeks the steelmakers have been obliged to refuse new business unless of an exceptionally urgent character, as the work at present in hand is sufficient to keep them fully employed for at least six months. The pressure continues to be particularly severe in the structural steel department, and with the coming of more open weather the demand from the constructional engineers has shown signs of broadening. The quantities of joists and sections which are passing into consumption directly they are produced are phenomenal and are said to be in excess of the tonnages distributed during the last war. In all parts of the country works are being extended to cope with the war effort and new ones built, and the programmes of this kind of construction are likely to keep the industry employed for many months. To this enormous demand must be added the increasing requirements of the shipyards. Shipbuilding, both naval and mercantile, is being intensively pressed forward at all the yards in the country and is absorbing very large tonnages of steel. The call for heavy and medium plates is particularly strong and, although all the mills are operating at capacity, there is some stringency in the supply, and none except priority orders have any chance of acceptance by the makers except on indefinite delivery terms. The consuming industries, apart from the shipyards, including locomotive builders, boiler markers and tank makers, have a large amount of work in hand—some of it for overseas destinations—and their requirements help to swell the demand. The sheet works have had an uninterrupted spell of full-time working for over a year, and there is no indication that this position will alter in the near future. Government and service requirements are large, and there is also a certain amount of export work on hand against old contracts. Conditions in the Yorkshire industry are as active as in any part of the country and the Sheffield steelworks are operating under great pressure. Apart from the demand for ordinary descriptions of steel, there is a persistent request for the special sorts with the production of which Sheffield is particularly identified. Service requirements, munition and armament production, are responsible for record outputs and works operations are being pressed to the limit. There is a large production of basic billets which are absorbed by the consuming works as they are turned out and in this department delivery dates are very extended. The call for acid carbon billets has expanded since the end of the year, and the completion of new orders cannot be promised in less than several months. There has been no relaxation in the pressure of the demand for ordinary descriptions of steel such as joists, sections, plates, etc., and requirements are outstripping production. Business in special and alloy steels appears to be only limited by the ability of the makers to supply.

Copper and Tin

The chief feature of the copper market in this country is the high rate of consumption. Consumers' requirements appear to be steadily expanding and although it is suggested that if the war does not become more active the Service requirements will lessen, at present there is no sign that this is taking place. There are no figures available to check any views which may be held, and which are based largely upon the experience or opinions of individual firms. It says much for the arrangements made by the Government that from the very commencement of the war there has been no stringency in the copper position. Licences are still carefully scrutinised, but this would seem to be a matter of precaution. Little copper, however, seems to be released for work which is not of national importance. The export of copper materials is at a low level, but recently Indian buyers were in the market for copper sheets. The world market has been quiet and easy. In the United States consumption is reported to be at a high level and the manufacturers of copper products are understood to be in a sound position with a considerable tonnage of orders on their books. Consumers in the United States, however, bought close upon 150,000 tons in February and it is thought that they are not likely to return to the market in strength until the latter part of May. Consumption in America is estimated to be at 70,000 tons per month. Prices are slightly easier and the export quotation has now slipped back to 11·35c. f.a.s. New York, from 11·60c. The domestic price is retained at 11·50c. Neutral countries which a few weeks ago were inquiring actively for copper now appear to have withdrawn from the market and the only noticeable demand comes from Scandinavia, Switzerland, and Spain, the quantities involved being comparatively small. . . . The tin market has been rather dull, chiefly because purchases by the United States have fallen off whilst the east has sold with some freedom at gradually decreasing prices. Some American buying developed in the middle of last week but did not persist and it is thought that consumers in that country had covered their needs for some time ahead. Consumers in the United States are not actively employed, but nevertheless steady consumption is proceeding. On April 1st, the International Tin Committee puts into force the 80 per cent. quota, and this should soon be reflected in a restriction of the rather heavy selling which has been taking place in the east. Business with Continental countries has been far from active, but this would seem to be largely because the issue of export licences to neutrals on the Continent is carefully supervised.

Lead and Spelter

There has been no change in the lead market for the past week or two. Large quantities of metal are passing into consumption in war work; but there is no difficulty in meeting the full requirements of the consuming trades. Practically the whole capacity of the works making lead products is engaged upon Government work although the output of the pipe and sheet makers is understood to have declined to some extent as a result of the fall in building operations. Export business is limited and firms which are not employed upon work arising from the war do not always find it easy to obtain licences. So far as supplies are concerned these have proved entirely adequate and it is generally believed that Empire resources will be sufficient to provide for the full requirements of this country during the war. In the United States the producers are reported to have well filled order books, but buying seems to have fallen off considerably. For this reason, perhaps, there has been a further reduction in the price to 50·5c. The American Bureau of Metal Statistics has issued preliminary figures for the world refinery production in 1939. The world output is given as 1,904,883 tons last year, compared with 1,845,636 tons in 1938. The figures for Russia and Japan included in this calculation are conjectural. . . . The spelter market in this country, if it can be called a market under wartime control, presents no new features. Most of the consuming trades are busily employed upon work of national importance, and are likely to remain so. Whilst there is sufficient spelter to meet all calls for essential needs, comparatively little metal is at the disposal of firms requiring it for ordinary commercial purposes. An announcement not without interest has been made by the Zinc Corporation, Ltd., which states that in common with other Empire producers it has been officially asked to discontinue the publication of production statistics. The Americans, however, continue to give figures and the American Bureau of Metal Statistics estimate that the world's total production, in short tons, in 1939, reached 1,877,614 tons, compared with 1,751,870 tons in 1938. In these figures the American domestic output is placed at 538,198 tons in 1939, against 456,990 tons in 1938.

Non-Ferrous Metal Prices

The official average prices in March for tin issued by the London Metal Exchange again show a rise over the figures for the previous month. The average price for cash tin was £8 17s. 11d. higher than in February; the three months' quotation being £7 17s. 9d. more, and the settlement price £8 16s. 11d. above the February average. No change took place in the official maximum prices for copper, lead, and spelter, fixed by the Controller of Non-Ferrous Metals. These are also given in the statement published by the London Metal Exchange, which is as follows:—

STANDARD TIN ...	Cash (Mean) £251 17s. 6d. 3 Months (Mean) £250 12s. 10$\frac{1}{10}$d. Settlement (Mean) £251 17s. 1$\frac{7}{10}$d.

The following prices for copper, lead, and spelter are the maximum prices fixed by the Controller of Non-Ferrous Metals:—

	£	s.	d.	
STANDARD COPPER—				
Electrolytic Copper ...	62	0	0	delivered buyers' premises
Electrolytic Wire Bars...	62	0	0	,, ,, ,,
Best Selected Copper ...	60	10	0	,, ,, ,,
Lead—Good Soft Pig ...	25	0	0	,, ,, ,,
(Foreign)				(duty paid)
Spelter—G.O.B.	25	15	0	delivered buyers' premises
(Foreign)				(duty paid)

French Engineering Notes

(From our own Correspondent in Paris)

Shipping

THE annual report on French shipping presented by Monsieur Marchegay at the general meeting of the Central Committee of French Shipowners dealt with the situation during 1939, down to the time of the mobilisation in September when the greater part of the shipping was taken over by the State. A comparison of these figures, he said, revealed the artificial character of shipping evolution that preceded the war. The world's tonnage at the end of June last was 69,439,000, an increase of 1,600,000 tons on the previous twelve months. At the same date, the tonnage under construction was 2,850,000, a figure which had rarely been exceeded. Nevertheless, the tonnage laid up was nearly 4,000,000, or double that of 1938. While, therefore, maritime traffic had remained stable for nearly two years, there was a continual increase in tonnage and in shipbuilding at a time when ships had to be laid up. The only conclusion to be reached from these anomalies was that since the end of June, 1938, merchant shipping was regarded as material necessary for national defence, and that the leading maritime Governments had constituted reserves without taking into account the evolution of shipping traffic. At about this time, the French Government put into operation its statute for the reconstruction of the merchant fleet with a programme of shipbuilding over a period of seven years and with more effective aid to shipowners than the short time allowances that had been offered previously. The building of half a million tons of ships was undertaken by the Government, and allowances offered to non-subsidised shipping were extended to ten years. All these arrangements were suspended on the outbreak of war. Since then non-subsidised ships of more than 500 tons had been run by their owners under contract with the State and under control of the direction of maritime transports, so that they had been practically requisitioned by the State in much the same way as subsidised shipping that was run directly by the State. Monsieur Marchegay is satisfied with the conditions of the contract which provides for the replacement of ships lost during the war and for the creation of a special account for annual payments to owners whose ships are returned to them after the war, the payment being continued until the ships are replaced. Nevertheless, he says that close attention must be given to the interests of shipowners after the war. It will be remembered that following the last war the State continued to control shipping for nearly two years with such unsatisfactory results that the experiment will certainly not be repeated.

The Saint-Cloud Bridge

The reconstructed bridge across the Seine at Saint-Cloud has been opened to traffic before being completely finished so that a dispersal of population from Paris may be the more easily carried out by way of the new motor road, if necessary. As explained during the earlier period of its construction, the bridge replaces the old stone bridge, and the work was complicated by the fact that the new bridge starts from the line of the old one on the Paris side of the river and bears a little to the left in order to widen the bend at the bottom of the hill to the tunnel which connects it with the motor road half way up the hill on the right. During construction, traffic was maintained by widening the old bridge for most of its length with girders on timber piers. The new bridge has five spans of 103ft. 6in. and two end spans of 46ft. Its length is 611ft. 9in. and width 97ft. 5in. The design offers some novelty. There are 24 cylindrical reinforced concrete piers, not much more than a metre in diameter, sunk in six transverse lines of four, each line carrying a reinforced concrete beam of a width equal to the diameter of the piers. On these beams are laid deep high tensile steel girders welded end on end and connected by cross girders which form two grids separated by an expansion gap at the centre of the bridge. This welded construction differs from that of the Neuilly bridge, lower down the Seine, which has fabricated arches of steel plate welded in the form of box girders. The Saint-Cloud bridge is, moreover, a straight metallic structure without heavy abutments. The reinforced concrete platform is similar in construction to that at Neuilly, though the concrete is more firmly secured to the grid deck by bent strips welded to the girders and their vertical ends cut longitudinally and twisted. Brackets are welded to the outside girders for the attachment of balustrade fittings which are all bolted, and the balustrades will be completely covered with dark bronze sheet in the form of filleted and curved panels. The balustrades widen out near the ends of the platform to provide easier access to traffic. There is still work to be done and a part of the old stone bridge remains to be dismantled, but there is nothing to interfere with the maximum traffic for which the bridge was designed. There is something attractive in the bridge with its appearance of simplicity and lightness, and it is well in keeping with the background of Saint-Cloud.

Export Trade

In order to obtain a licence to export goods, the application has to pass successively through five Ministerial departments, and the work of preparing applications with a mass of detail and waiting while the departments attended to them, left manufacturers with a feeling that the routine deterred them from exporting at all. Nevertheless, the control must be maintained, and the Minister of Commerce recently hastened formalities by creating inspectors who serve as intermediaries between exporters and the Government departments concerned. He now proposes to take the load off exporters by constituting a Superior Export Council which will comprise representatives of the Ministries that examine applications, two senators, and two deputies, and representatives of industry and trade. It will not only have authority to grant applications for export licences without loss of time, but will also be in permanent contact with the different industries and trades and their organisations in order to follow the trend of the export trade and do what is necessary to develop it.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 1s. each.

The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES

518,206. September 24th, 1938.—BEARINGS, Heraeus Vacuumschmelze Aktiengesellschaft, Hanau, A.M., Germany, Dr. Ing. Werner Hessenbruch, Danzigerstrasse 4, Hanau a Main, Germany, and Dr. Wilhelm Rohn, of Dammstrasse 8, Hanau a Main, Germany.

Copper-lead bearings usually consist of a supporting steel shell into which a thin lining of the copper-lead alloy has been cast. Owing to the large difference between the melting points of copper and lead it is extremely difficult to have full control of the structure of the solidified alloy and to obtain a homogeneous and fine distribution of the lead particles through the skeleton of the copper. According to the method described, the skeleton of a bearing is made of cloth woven from copper or copper alloy wire. By suitable choice of the diameter of the wire and the width of the meshes of the cloth the structure of the bearing can be accurately controlled with regard to the proportion of copper to lead and with regard to the size and regular distribution of the lead particles. According to the invention, one or more layers of cloth woven from copper or alloy wire are supported by means of a steel shell (which may be superficially tinned) and impregnated by dipping the whole into molten lead. The cloth may be wound on or in the shell. If a lower percentage of lead is desired the copper-wire cloth can first be passed through rollers in order to flatten the cross points of the longitudinal and transverse wires. To finish the bearing for use it is not necessary to machine any surplus out of the crude bearing, but the so called press finishing can be used which consists in pressing a mandrel or a ball, the diameter of which corresponds to the desired final diameter of the bearing, through the opening of the bearing. Instead of making the skeleton of the bearing of copper, it may be made of tin-copper-bronze or phosphorus-copper-bronze or beryllium-copper-bronze, and the lead may be alloyed with antimony or bismuth or tin or sodium or calcium, &c.—*February 20th*, 1940.

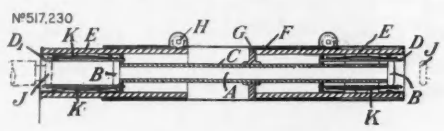
518,284. August 20th, 1938.—VALVE GUIDES, Hardy, Spicer and Co., Ltd., and William Edwin Sparrow, both of the company's address, Birch Road, Witton, Birmingham, 6.

In the method of forming a valve guide, according to the invention, powdered sponge iron is used preferably of about 98 per cent. purity. The size of the particles is preferably such that they will pass through a mesh containing a hundred apertures per linear inch. The requisite quantity of powder is moulded to shape under a pressure up to 25 tons per square inch. It is then heated to a predetermined degree, in the vicinity of 1100 deg. Cent. The guide is then subjected to what is termed a sizing operation which follows closely the same procedure as the forming of the original piece. This sizing operation is performed after the valve guide has been impregnated with lubricant. The impregnation is preferably carried out in a partial vacuum, the articles being immersed at a temperature of about 80 deg. Cent. in a non-acid, medium-heavy lubricant. An advantage of producing the guides from powdered sponge iron is that the finished article is very porous and, when impregnated with a lubricant, will become almost self-lubricating. The extent of the porosity, it is said, can be varied during manufacture, even to the extent of being able to absorb approximately 30 per cent. of its volume of lubricant. Moreover, as powdered sponge iron lends itself readily to moulding under pressure, the valve guides can be produced in their finished state and machining or other operations are obviated.—*February 22nd*, 1940.

SWITCHGEAR

517,230. July 22nd, 1938.—IMPROVEMENTS IN METAL CLAD ELECTRIC SWITCHGEAR, British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2, and Eugene David Regis, 43, Tanfield Avenue, Cricklewood, London, N.W.2.

An isolating element for incorporating into metal clad electric switchgear is described with reference to the accompanying drawing, which shows a disconnecting device comprising an intermediate conductor, consisting of a metal rod A having contacts B at the ends, and surrounded by insulation C. Two end conductors D and D_1 are each carried by an insulating tube E adapted to telescope with the intermediate conductor, and slidably supported within an outer earthed metal casing F. The casing is carried by an insulating member G which is shown as embracing the insulation on the conductor. The



metal casing supports the tubes E and also carries operating mechanism which may consist of spur wheels engaging racks on the outer surfaces of the insulating tubes whereby they are simultaneously movable towards or away from one another to effect isolation of the two adjacent parts of the gear or to connect them together respectively. The adjacent parts of the gear are represented by contact elements J, and the device is shown in a position in which the left-hand conductor is extended to engage the appropriate contact element while the right-hand conductor is still within the casing. The conductors are each mounted with a limited degree of freedom within the tubes to allow the contact surfaces readily to align with the associated parts of gear. The conductors are supported by bowed springs K, pins being provided for restraining the endwise movement of the conductors within the tubes.—*January 24th*, 1940.

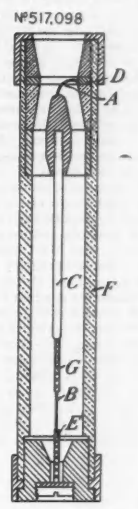
ELECTRICAL APPLIANCES

517,905. September 2nd, 1938.—INDICATORS FOR ELECTRIC CARTRIDGE FUSE LINKS, Lawson Beck, Ltd., Queensway, Team Valley Trading Estate, Gateshead-on-Tyne, and Anthony James Allan Beck, Claremont, Swansfield Park Road, Alnwick.

The cartridge fuse link described has on it an indicator in which a wire or strip of material is adapted to volatilise instantly when a predetermined voltage is impressed across it. The wire is totally enclosed in an insulating sleeving of transparent or translucent material on the inner surface of which the products of the wire on short circuit are deposited causing it to have a different appearance, and giving a clearly visible means of determining when the fuse element has blown.—*February 12th*, 1940.

517,098. August 19th, 1938. ELECTRIC SAFETY FUSES, Emil Lange, of 43, Im Dickricht, Berlin-Zehlendorf, Germany.

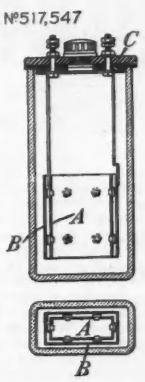
An electric safety fuse is described in this specification of the type in which the rupture of the arc is effected by means of a blast or jet which is formed by the arc itself. For this purpose two fuse wires are arranged in an insulating casing, the arc at one wire being ruptured by the blast or jet caused by the fusing of the other wire on the device entering into operation. The device operates as follows:—On the fusing of the wires A and B, an arc is formed between the rod C and the contact ring D as well as between the cable E and the rod C. An increase of pressure occurs in the casing F which ejects the non-preliminarily heated rupturing medium through the outlet of the casing, and thereby causes a rupture of the arc between ring D and rod C. The initial pressure created by the arc formed by the fusing of the wire B would generally be sufficient to rupture the arc between the contacts C and D. To ensure, however, the absolute reliability of the device, the flexible cables E and G will by their displacement still further increase the length of the arc, and thereby increase the blast. A harmful increase of pressure which would cause a destruction of the casing will not occur. By reason of the flexible character of the cable G at the fusing point the cable will be forced upwards by the blast surrounding the arc. The arc will thereby be extended lengthwise. This has the advantage that the increase of pressure in the casing grows correspondingly. The rupture of the arc at the fuse wire A is thus facilitated so that it takes place in the growing blast.—*January 19th*, 1940.



BATTERIES AND ACCUMULATORS

517,547. July 29th, 1938.—ELECTRIC CELLS, Batteries, Ltd., Hunt End Works, Enfield Road, Hunt End, Redditch, and Martin Dybeck, of the company's address.

An electric cell constructed according to one embodiment of the present invention is shown in the accompanying drawing. Two electrodes A and B, each of box-like formation, are open at top and bottom, one electrode being within the other, the transverse section being oblong. Each electrode is attached

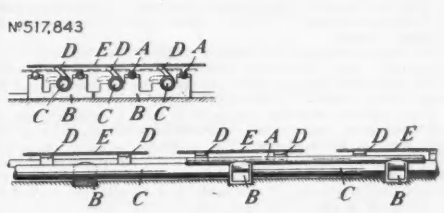


to the insulating cover C by a vertical conductor rod and the two are contained within a glass or other container and submerged in the electrolyte. To insulate the inner electrode from its neighbour a number of headed studs are set in the inner component, the arrangement being such that the heads lie between the electrodes for spacing and insulating purposes.—*February 1st*, 1940.

FURNACES

517,843. August 10th, 1938.—CONVEYOR MECHANISMS, Gibbons Brothers, Ltd., Dibdale Works, Dudley, Baldwins, Ltd., Shell-Mex House, Victoria Embankment, London, W.C.2, and Walter Reginald Marchant, A.M.I. Mech. E., 87, Sunnybank Road, Griffithstown, Pontypool, Monmouthshire.

The conveyor mechanism referred to is of the kind adapted to advance articles in a series of steps by, or through the medium of, members reciprocated mechanically. In the construction illustrated the mechanism is applied for feeding articles through a furnace. It includes a track along the floor of the furnace. This track comprises one or more pairs of steel skids or rails A extending in spaced parallel relationship through the length of the furnace. Preferably the track includes two pairs of

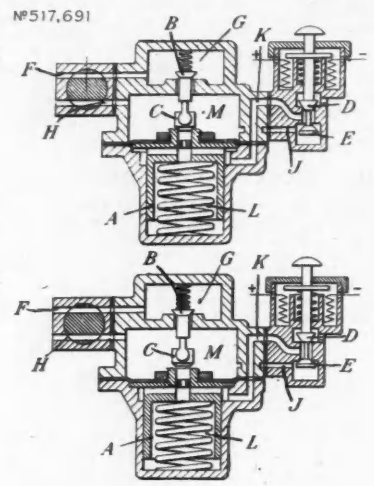


skids as shown supported upon stools or bearings B on the floors. Between each two adjacent skids is mounted a carrier bar C, supported by the bearings, for longitudinal reciprocating movement along the furnace and for limited angular or tilting movement about the axis of reciprocation. Each of these carrier bars is provided with a series of spaced projections D projecting tangentially from the surface of the carrier bar. These projections are adapted for engaging with and moving the articles, such as the plates E, to be treated and may be suitably shaped to facilitate engagement with such articles. Any operating mechanism may be provided for moving the carrier bars which are, preferably, interconnected and adapted for simultaneous operation.—*February 9th*, 1940.

TRAMWAYS AND RAILWAYS

517,691. August 4th, 1938.—Improvements to Fluid Pressure Braking Apparatus for Railway Vehicles, Westinghouse Brake and Signal Company, Ltd., 82, York Way, King's Cross, London, N.1.

In the braking of railway vehicles the braking effort must not be greater than the adhesion existing between wheel and rail, otherwise the wheels would skid. To stop a train running at high speed, it is necessary to be able initially to make use of a very high braking pressure, and at the same time to be able to reduce such pressure to normal values in the final stage of stopping so as to prevent wheel skid. According to the invention, improved arrangements are provided for automatically partially releasing fluid pressure from the brake cylinder during the stopping of the train. The device comprises two elements, namely, an entirely pneumatic element which controls the supply conduit to the brake cylinder, and an electro-pneumatic element, the action of which depends upon the speed of the vehicle and determines the operation of the pneumatic element. According to the example illustrated, the pneumatic element consists of a body in which is a slidable piston A actuating two interconnected valves. The upper valve B controls communication between the distributor (triple valve) and the brake cylinder, and the lower valve C controls the eventual release of fluid pressure from the brake cylinder to the atmosphere through a choke passage. A spring in the piston maintains it when the brake is released in its uppermost position so that the upper valve is open and the lower valve closed. The electro-pneumatic element consists of an electro-magnet, actuating two interconnected valves. When the electro-magnet circuit is energised, both valves D and E are forced downwards, thus closing D and opening E. When this circuit is de-energised, a small spring lifts both valves, closing E and opening D. A centrifugal device is adopted for energising the electro-magnet circuit when the speed is higher than the predetermined speed, for

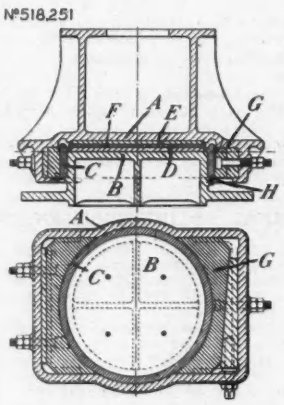


example, 50 km. per hour. When the train is running at high speed (see upper view), the circuit is energised, and consequently both valves D and E are in their lowest position. The uppermost valve is closed, whilst the other is open. If a brake application is then made, the fluid pressure supplied by the distributor by conduit F flows through the isolating cock to chamber G. Thence through conduit H pressure flows to the brake cylinder; at the same time fluid passes through conduit J, valve E, conduit K, to chamber L under the piston A. The pressure acting on both sides of the piston will thus be the same, and the spring will maintain it in its uppermost position. The feed of fluid pressure to the brake cylinder will therefore take place without any limitation, and in the case of a rapid brake application the pressure in the brake cylinder will reach its predetermined maximum value in a few seconds. When the speed is reduced to less than the pre-determined speed the circuit of the electro-magnet will be de-energised (see lower view) and bring the valve E on to its seat, cutting off communication between chambers M and L, and opening valve C, which will connect chamber L to atmosphere. The pressure acting in the chamber above A (and thereby in the brake cylinder) is therefore only opposed by the spring, which is set so as to correspond to a brake cylinder pressure of reduced value which will not cause skidding even at low speed. The greater pressure acting in the brake cylinder and therefore also in chamber M will act in such a manner that the spring will be overcome, and the piston will be pushed downwards, allowing the brake cylinder to exhaust to atmosphere through the choke, since valve C is raised from its seat. The release of pressure from the brake cylinder will cease when its reduced pressure acting on the piston is balanced by the spring. This reduced pressure corresponds to a force of application of approximately 75 per cent. of the load, which is sufficient to prevent wheel skidding. This reduced degree of brake application is maintained against brake cylinder leakage. The device does not affect the release of the brake.—*February 6th*, 1940.

LOCOMOTIVES

518,251. December 1st, 1938.—Articulated Locomotives, Beyer, Peacock and Co., Ltd., Gorton, Manchester, and Samuel Jackson, "Brevik," 260, Bramhall Lane, Stockport, Chester.

The pivot centres of articulated vehicles have hitherto been constructed with the female pivot centre on the underside, whilst the male pivot centre is located thereabove. This construction necessarily leaves the upper edges of the vertical working surfaces between the centres open to easy ingress of coal dust, grit, and similar harmful substances which cause rapid wear of the surfaces. The invention aims at obviating this undue wear by providing efficient and adequate protection against the ingress of foreign matter. With this end in view the relative positions of the male and female pivot centres are reversed so that the open edges of the vertical working surfaces are on the underside while the horizontal working surfaces are located above the vertical working surfaces. Referring to the drawings, the female pivot centre A is arranged above the male pivot centre B. The latter has a renewable wearing ring C fixed to its periphery and a renewable wearing piece D attached to its upper horizontal surface. The female pivot centre has a similar renewable wearing piece E attached to its lower horizontal surface and a loose wearing piece F is arranged between the wearing pieces as shown. Adjustable renewable wearing blocks G are fitted to the vertical surface of the female pivot centre, one form of such block being shown on either side of the centre line of the drawings. The wearing ring C projects above the horizontal wearing surfaces, as a peripheral rim for the male pivot centre, to form an annular recess or well to receive and retain lubricant, thereby ensuring efficient lubrication of the horizontal working surfaces. A plate H is attached to the underside of the pivot centres to

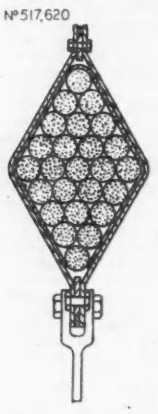


provide additional protection for the vertical working surfaces and to retain lubricant.—*February 21st*, 1940.

BUILDING

517,620. July 30th, 1938.—Improvements relating to a Catenary Cable Construction for Suspension Bridges, William Lindsay Hamilton, 3, Belhaven Terrace, Glasgow, Scotland.

It is the object of this invention to provide an improved catenary cable construction incorporating individual cables arranged and maintained in an improved relationship whereby each individual cable takes up its proper share of the load

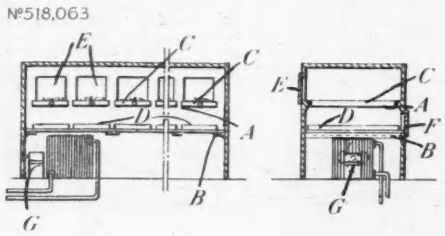


effectively without relative slip of the cables. It comprises a group of individual cables having a bottom and top cable and rows of cables interposed therebetween; the number of cables in each row decreasing by one above and below the middle row of cables of the group, the cables in adjacent rows being staggered. The group of cables is maintained in diamond formation by means of box frames as shown in the accompanying drawing.—*February 5th*, 1940.

MISCELLANEOUS

518,063. August 15th, 1938.—Grass-Drying Plants, Charles Henry Roberts, "Boothby," Brampton, Cumberland, and Richard Papps, "Ramleh," Brampton, Cumberland.

In the construction shown, racks A and B support the grass. The upper rack consists of trays C having spigots rotatably mounted on opposite walls of the chamber so that they may be inverted. The lower rank comprises removable trays D.



The grass is introduced through doors E at one side of the chamber on to the upper trays and after drying has proceeded for some time the grass is precipitated on to the lower trays by turning the upper trays about their pivotal mounting. The grass is thus redistributed on to the lower trays for the remainder of the drying process and is then withdrawn through a number of doors F. The grass is dried by air circulated by means of the fan G through a radiator.—*February 16th*, 1940.

518,351. September 19th, 1938.—Scraper Drag Systems, International Combustion, Ltd., Aldwych House, Aldwych, London, W.C.2, and Edwin George Ennals, 29, Mostyn Avenue, Littleover, Derby.

The known arrangements of scraper drag systems involve a considerable amount of initial preparation of the site before operations can be commenced, for example a rail track must be laid down and/or a winch house and sheave posts must be fixedly installed on the ground. An object of this invention is to provide an arrangement which permits a system to be applied to cases where the amount of material to be handled does not justify the expense of preparing the site. This is done by mounting either the winch or a back sheave post on a railless vehicle, such as a tractor having a continuous track, and providing the vehicle with a thrust shield which is adapted to abut on a pile of material and thereby anchor it while the scraper is being hauled. Where the winch is mounted on the vehicle, its engine may also be arranged to propel the vehicle. The thrust shield may be arranged to form one side of a hopper for receiving the material drawn by the scraper and provision made for readily releasing the cables from the vehicle in order to permit the latter to convey the material to a desired position. —*February 23rd*, 1940.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Air Raid Protection Institute

Tuesday, April 9th.—Royal Society of Arts, John Street, Adelphi, W.C.2. "Dual Purpose Structures," S. Clough. 8 p.m.

Association of Special Libraries and Information Bureaux

Friday, April 12th.—Science Museum, South Kensington, S.W.7. "The Developments of Microphotography in War Conditions," L. Sayce. 5 p.m.

Diesel Engine Users' Association

Thursday, April 11th.—Caxton Hall, Westminster, S.W.1 Discussion on 1939 Bulletin. 2.30 p.m.

Illuminating Engineering Society

Tuesday, April 9th.—E.L.M.A. Lighting Service Bureau, 2, Savoy Hill, W.C.2. "The Photometric Properties of Luminescent Materials," W. E. Harper, M. B. Robinson, and J. N. Bowtell. 6 p.m.

Institution of Automobile Engineers

Tuesday, April 9th.—Luton Centre. George Hotel, Luton. "The Use of Gas as a Fuel for Motor Vehicles," J. S. Clarke.

Friday, April 12th.—Derby Centre. Royal Hotel, Derby. Ball. 8 p.m.

Tuesday, April 23rd.—Birmingham Centre. James Watt Memorial Institute, Great Charles Street, Birmingham. "Some Problems We Meet," L. H. Dawtrey. 7 p.m.

Institution of Chemical Engineers

To-day, April 5th.—Hotel Victoria, Northumberland Avenue, W.C.2. Annual Corporate Meeting and Presidential Address. 11 a.m. Luncheon, 12.45 for 1 p.m.

Institution of Civil Engineers

Tuesday, April 23rd.—Great George Street, Westminster, S.W.1. "The Remodelling of the Assiut Barrage, Egypt," J. E. Bostock. 5.30 p.m.

Institution of Electrical Engineers

To-day, April 5th.—Meter and Instrument Section. Savoy Place, Victoria Embankment, W.C.2. "Developments in Surge Recording by means of the Klydonograph," (E.R.A. Report), J. L. Candler. 6 p.m.

Thursday, April 11th. Savoy Place, Victoria Embankment, W.C.2. "The High-Rupturing-Capacity Cartridge Fuse, with special reference to Short-Circuit Performance," J. W. Gibson. 6 p.m.

Friday, April 19th.—Transmission Section. Waldorf Hotel, Aldwych, W.C.2. Dinner. 7 for 7.15 p.m.

Institution of Engineers-in-Charge

Friday, April 19th.—Holborn Restaurant, London, W.C.1. Annual Dinner. 6 for 6.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, April 9th.—39, Elmbank Crescent, Glasgow. "Electrolytic Action on Steel in Sea Water," J. H. Paterson. 6.30 p.m.

Institution of Mechanical Engineers

Friday, April 19th.—Storey's Gate, Westminster, S.W.1. "The Problems of the Singing Propeller," W. Kerr, J. F. Shannon, and R. N. Arnold. 6 p.m.

Institution of Production Engineers

Saturday, April 13th.—Yorkshire Section. Hotel Metropole, Leeds. "The Electrical Engineer and Production," A. F. Carter.

Junior Institution of Engineers

To-day, April 5th.—Sheffield Section. Metallurgical Club, West Street, Sheffield. "Noise, Intelligible and Otherwise," D. Taylor. 7.30 p.m.

Friday, April 12th.—39, Victoria Street, S.W.1. "Fluid Flow in Pipe Lines and Fittings," S. J. Moore. 6.30 p.m.

Old Centralians

Wednesday, April 24th.—Institution of Mechanical Engineers, Storey's Gate, S.W.1. Annual General Meeting. 5.30 p.m.

Newcomen Society

Wednesday, April 24th.—Science Museum, South Kensington, S.W.7. "The Earliest Industrial Use of Coal," T. T. Read and "A Picardy Post Mill, 1630," Enid and Rex Wailes. 2.30 p.m.

North-East Coast Institution of Engineers and Shipbuilders

Wednesday, April 10th.—Student Section. Bolbec Hall, Newcastle-upon-Tyne. "Superchargers," H. Chilton. 6.45 p.m.

Royal Aeronautical Society

Friday, April 12th.—Institution of Electrical Engineers, Savoy Place, Victoria Embankment, W.C.2. "Flight Refuelling," Sir Alan Cobham and M. Langley. 6.30 p.m.

PERSONAL AND BUSINESS ANNOUNCEMENTS

The Coal Utilisation Joint Council informs us that the address of its head office and southern branch is now 99, Aldwych, London, W.C.2.

The Brush Electrical Engineering Company, Ltd., announces that it has a register of the students of its associated company, Petters, Ltd., and also the address of many old "Brush" students. The information, however, is incomplete, and therefore the Brush company requests all ex-Brush and Petter pupils, students, or apprentices to communicate with it.

CATALOGUES

Gent and Co., Ltd., Faraday Works, Leicester. Booklet, on "Tangent" electrical products including bells, indicators, relays, pushes, signalling systems, &c.

Edison Swan Electric Company, Ltd., 155, Charing Cross Road, London, W.C.2. A leaflet describing the "Ediswan" 80 watt fluorescent discharge tube and equipment.

The Harland Engineering Company, Ltd., Alloa, Scotland. Publications × 109/3091 "Large D.C. Machines"; × 63b/3812 "Borehole and Deepwell Pumps"; × 65a/3901 "Duoglide Two-Stage Horizontal Pumps"; × 60a/3901 "Spiroglide" Multi-Stage Horizontal Pumps; and also a pamphlet "Trailer Fire Pumps."